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ORIGINAL ARTICLE

Acute effects of sprint training for hamstrings injury prevention on male college soccer players

Ryo Iwasaki . *Faculty of Sports and Health Science. Fukuoka University. Japan.*
Naoki Takahashi. *United Graduate School of Education. Tokyo Gakugei University. Japan.*
Aomori Prefectural Institute for Sports Science. Japan.
Hironari Shinkai. *Faculty of Education. Tokyo Gakugei University. Japan.*

ABSTRACT

In soccer, the hamstring is one of the most common injury portions. Among the various interventions, it can be assumed that modification of sprinting movement is directly helpful in hamstring injuries. The acute effects of sprinting interventions would be useful for pre-match interventions if they were immediate. The present study aimed to clarify the acute effects of sprint training for hamstring injury prevention on a collegiate soccer player. A total of twenty–seven male collegiate soccer players participated in the present study. Participants performed a 30 m sprint test as a pre-test after warming up. Subsequently, an hour-long sprint training session, targeting the modification of movements associated with hamstring injuries, was conducted, followed by a post-test involving a 30 m sprint. From these trials, 30 m time and kinematic variables associated with a hamstring injury; trunk angle, thigh angle and shank angle, were computed. The results revealed a significant positive modification in the trunk angle between the pre-test and post-test sessions. However, no marked differences were observed in 30 m time and other kinematic data. Therefore, sprinting modification was shown to have an acute effect on improving trunk angle without affecting the running speed.
Keywords: Performance analysis of sport, Football, Training intervention, Kinematics.

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Corresponding author. *Faculty of Sports and Health Science. Fukuoka University. Japan.*
E-mail: r-iwasaki@fukuoka-u.ac.jp
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INTRODUCTION

In soccer, field players travel 10 – 13 km in total per game (Bangsbo et al., 2006). Sprint accounts for approximately 0.5 – 3.0 % of this overall distance (Stølen et al., 2005). Notably, recent professional soccer games have witnessed shorter, faster and more frequent sprints (Barens et al., 2014; Haugen et al., 2019). The ability to sprint has emerged as an essential factor associated with score and game outcome (Barens et al., 2014; Haugen, 2017). Consequently, sprint training for soccer players has garnered considerable attention in recent years (Mendiguchia et al., 2022).

Linear or high-speed sprints often give rise to various sports-related injuries (Gronwald et al., 2022). Among them, hamstring injuries are representative, with the thigh (specifically the biceps femoris muscle) being the most commonly affected area (Gronwald et al., 2022). It has been reported that hamstring injuries occur frequently in soccer players, and a significant proportion of these injuries result from non-contact situations (Opar et al., 2012; Van Beijsterveldt AMC et al., 2013). The main risk factors associated with hamstring injuries are considered to be the angle of forward tilt of the trunk, the angle of the thigh swinging up and the angle of the shank forward swing (Gronwald et al., 2022; Schuermans et al., 2017). These movements cause stretching of the hamstrings and are therefore considered to cause stretch-related hamstring strain patterns. As hamstring stretching is primarily caused by simultaneous excessive thigh lifting and excessive forward tilt of the trunk. In addition, eccentric loading of the hamstrings increases throughout the front- and early stance phases of the sprint cycle (Schuermans et al., 2017). Therefore, improving sprint movement during these phases may contribute to the prevention of hamstring injuries. It has also been suggested that sprint movements in soccer players differ from optimal movements and share characteristics with movements identified as risk factors for sports injuries (Okudaira et al., 2020). These findings underscore the significance of sprint training in injury prevention for soccer players. These suggest the importance of sprint training for soccer players in injury prevention. Against this background, the number of muscle injuries, such as hamstring injury, has not yet decreased, despite efforts to implement prevention interventions (Ekstrand et al., 2021).

Traditionally, the primary goal of sprint training has been to enhance sprint times and cultivate efficient movements to improve running speed (Haugen, 2017). However, the previous study (Mendiguchia et al., 2022) recently reported that a 6-week training intervention conducted to prevent hamstring injury showed improvement in movements associated with a hamstring injury. Nevertheless, this training program involves a comprehensive approach encompassing sprint technique, strength and conditioning, and physical therapy, making it challenging to implement during regular training sessions. The previous study suggested the effectiveness of sprint training over eccentric training, such as Nordic hamstring exercise (Mendiguchia et al., 2021). Therefore, it is reasonable to anticipate that a focused approach targeting the sprint technique could directly enhance movements associated with the risk factors for a hamstring injury. If intensive and short-term sprint training is found to contribute to modified sprint techniques, it would be a great help for improvement and screening immediately before a game. Thus, the present study concentrates on the acute effects of sprint training, as they are immediately applicable in training sessions. The present study aimed to clarify the acute effects of sprint training in preventing hamstring injury in soccer players. We hypothesised that the sprint training intervention would immediately improve sprint movements associated with a hamstring injury.

METHODS

Participants

Twenty–seven male soccer players participated in the present study (age: 19.9 ± 1.3 years, body height: 1.73 ± 0.04 m, body mass: 68.4 ± 5.3 kg). They were part of the same team competing in the 2nd division in the Regional University league. During the preceding three months, none of the participants had experienced any trunk or lower limb injuries. Following institutional ethical approval, which adhered to the standards of the journal and the Declaration of Helsinki, each participant gave written informed consent prior to the commencement of testing.

Measurements

After a 20 min individualised warm-up, each participant performed a 30 m sprint test as a pre-test. The participants were instructed to run as fast as possible. Then, the participants underwent 1 hour of sprint training to improve movements associated with a hamstring injury (i.e., excessive forward tilt of the trunk, excessive thigh lifting and excessive forward swing of the shank). A partially modified sprint training was implemented based on the previous study (Mendiguchia et al., 2022). These sprint trainings were based on the principles of front-side mechanics (Mann and Murphy, 2015). The front-side mechanics seeks to maximise leg motions occurring in front of the vertical torso line while minimising actions occurring behind that line throughout the sprint cycle. This technical model is characterised by maintaining an upright trunk and a neutral pelvic posture. Table 1 shows the training program. Post-test was conducted after the sprint training. In both tests, the start timing was at the participants' discretion. At the start, the front leg of the participants was placed on a matte switch (4assist, Japan), and a LED light (4assist, Japan) which was electrically synchronised to the matte switch, was turned off when the leg left the matte switch.

Table 1. Training program in the present study.

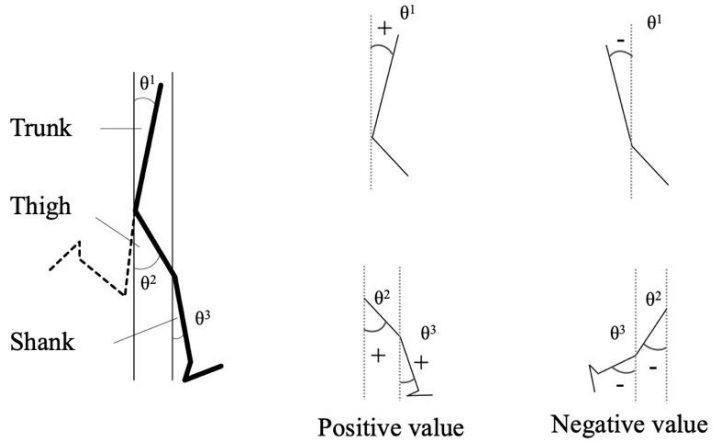
No.	Training contents (Concepts)	Target movement to be modified
1	Walking and running with upright posture (Understanding the front-side mechanics)	Excessive forward tilt of the trunk
2	Rebound jump (Ankle stiffness and avoiding the heel strike)	Excessive forward swing of the shank
3	Dribble (knee lift) (Learning punch the swing leg into the ground)	Excessive thigh lifting
4	Skipping (Learning the scissors action with upright trunk posture)	Excessive forward tilt of the trunk and forward swing of the shank

Six markers were attached to the right side of participants, including the shoulder, hip, knee, ankle, heel and toe. Images of the sagittal plane motion of both tests were obtained at 240 Hz using a high-speed camera (DSC-RX10, SONY, Japan) placed on the right side between 20 m and 30 m. The 30 m sprint times were obtained using a high-speed camera (FDR-AX40, SONY, Japan) placed on the right side of the goal, panning at 120 Hz (Figure 1).

Procedures

All body markers were digitised using motion analysis software (Frame–DIAS V, DKH, Japan). The coordinates of the markers obtained by two-dimensional Direct Linear Transformation (Walton, 1981) were smoothed using a fourth-order Butterworth low-pass digital filter with cut-off frequencies of 10.0–15.0 Hz.

Cut-off frequencies were determined from residual analysis (Winter, 2009). The sprint movements in the 20 m – 30 m section were analysed. The stride cycle was defined as the period from the stance leg contact to the free leg contact.



Note. The area denoted by the dotted line corresponds to the analysis phase.

Figure 1. Experimental setup.

Data analysis

The 30 m sprint times were calculated using the number of frames from the instant the LED light was turned off to the instant the torso of the participant passed the finish line. The step length and step frequency during the step cycle were calculated as spatiotemporal variables. The sprint velocity of the analysed portion was calculated as the product of step length and step frequency.

The trunk and lower limb angles associated with hamstring injury through the analysed portion were calculated (Gronwald et al., 2022; Schuermans et al., 2017). Three angles were defined as segmental angles between the vertical and the trunk segment (trunk angle), the thigh segment (thigh angle) and the shank segment (shank angle) (Figure 2). The maximum trunk angle and the thigh angle during the one-step cycle were calculated. In the shank angle, the maximum angle just before ground contact was calculated.

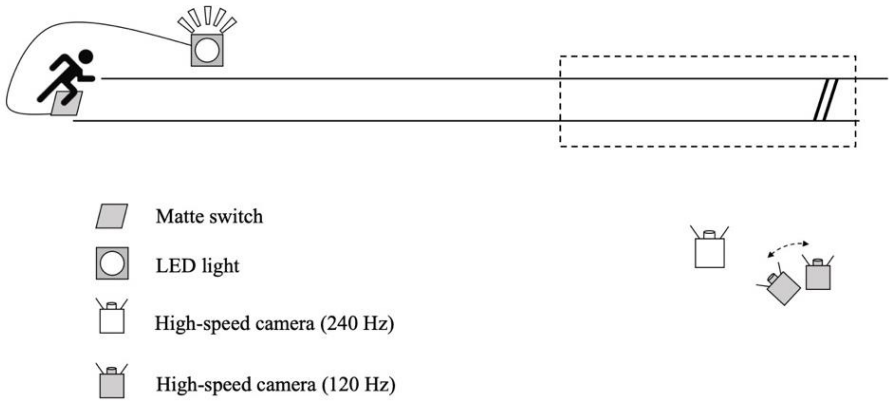


Figure 2. Definition of the trunk and lower limb movements.

Statistical analysis

All variables are presented as mean ± standard deviation (SD). Data normality was analysed using Shapiro–Wilk test. Student's paired *t*–tests were used to assess the differences for parametric data (Shapiro–Wilk test, $p > .05$). If the data normality was not confirmed (Shapiro–Wilk test, $p < .05$), Wilcoxon signed-rank tests were used. Cohen's *d* was used to describe the effect size (Cohen, 1992) with the following classifications (Sawilowsky, 2009): small (≦ 0.49), medium (0.50–0.79), large (0.80–1.19), very large (1.20–1.99), and huge (≧ 2.00). The level of significance was set at $\alpha < 0.05$. To control the family-wise error rate, the alpha level of each *t*-test was adjusted with the Holm method. All Statistical analyses were performed using EZR (Kanda, 2005, version 1.37; Saitama Medical Center, Jichi Medical University), which is a graphical interface for R (The R Foundation for Statistical Computing, Vienna, Austria) designed to add statistical functions frequently used in biostatistics.

RESULTS

Table 2 shows the changes in sprint performance and sprint movements between the pre-test and post-test. There were no significant changes in sprint performance and related spatiotemporal variables. The trunk angle was significantly lower in the post-test than in the pre-test. No marked differences were observed in the thigh and shank angles between the pre-test and post-test.

Table 2. Changes in sprint performance and sprint movements between pre-test and post-test.

Variable	Pre-test	Post-test	*p*-value	Cohen's *d*
30 m time (s)	4.17 (0.12)	4.17 (0.11)	.767	0.18
Step length (m)	1.80 (0.09)	1.82 (0.10)	.152	0.11
Step frequency (Hz)	4.53 (0.26)	4.51 (0.23)	.554	0.19
Velocity (m/s)	8.15 (0.41)	8.21 (0.42)	.505	0.03
Trunk angle (deg)	25.4 (3.9)	22.7 (4.5)	.001*	0.64
Thigh angle (deg)	57.3 (5.7)	59.1 (6.8)	.059	0.29
Shank angle (deg)	8.49 (6.43)	9.70 (5.86)	.071	0.20

*Note. Values are expressed as the mean (standard deviation). * Significant difference between pre-test and post-test.*

DISCUSSION

The present study aimed to clarify the acute effects of sprint training on preventing hamstring injury in soccer players. We found that the sprint training intervention for preventing hamstrings injury affected trunk movement immediately (Table 2). On the other hand, there was no change in thigh and shank angles and no immediate improvement in sprint performance. Therefore, sprint training intervention aimed at injury prevention in soccer players was shown to have an acute effect on improving trunk movement without decreasing sprint performance. These results partially supported our initial hypothesis.

The previous study indicated that the 6-week multimodal training program improved sprint performance and reduced the risk of muscle strain (Mendiguchia et al., 2022). The only disadvantage of their study is that it is not easy to implement into training sessions because of the complex nature of the training program. In their study, a 6-week training intervention resulted in an improvement of the pelvic tilt angle by approximately 6 degrees. In the present study program, a decrease in trunk angle by approximately 3 degrees (i.e., retention of upright posture) was observed. Another previous study reported that instability of the pelvis and trunk were associated with the hamstring injury (Schuermans et al., 2017). Therefore, the present study suggests that

sprint training, even if only short-term, may be effective in the prevention of hamstring injury in soccer players by improving the trunk angle. The report of the previous study was characteristic of athletes with a history of hamstring injury (Schuermans et al., 2017). Indeed, among the subjects in the present study, those at higher risk with a mean greater than + 1SD (i.e., having a potentially high risk of a hamstring injury in the subjects) showed a large benefit in the reduction of trunk angle (n = 9, pre-test: 29.7 ± 1.2 deg., post-test: 26.2 ± 3.1 deg., p = .025, d =1.47). Therefore, it can be speculated that sprint training may be effective, especially for athletes with a history of a hamstring injury or having a potentially high-risk movement.

While there was a change in the trunk angle between the pre-test and post-test, there was no change in the thigh and shank angles. Regarding thigh movement during sprinting, it is related to sprint performance (Clark et al, 2020; Clark et al, 2021) as well as a hamstring injury. Excessive lifting of the thighs causes stretching of the hamstring, which may contribute to a hamstring injury. However, the thigh inevitably lifts upward because of the need to recover the swing leg quickly as running speed increases (Clark et al, 2020; Clark et al, 2021). Therefore, it is a very difficult task to make the thigh angle both speed-enhancing and injury-prevention. In the present study, it is assumed that since there was no change in thigh motion during sprinting, there was no change in running speed. In addition, shank movement has been associated with running speed (Nagahara et al., 2014). In maximum acceleration sprinting, the acceleration phase is divided into three sections (i.e., initial, middle and final sections), each contributing differently to running speed. The movement of the shank plays a role in increasing running speed in all sections (Nagahara et al., 2014). Therefore, it is likely that the absence of changes in running speed resulted in no significant alterations in shank movement. Additionally, the angles of the thigh and shank may not have been sufficiently large to be considered risk factors for hamstring injury. As a result, future research investigating the acute effects of sprint training on soccer players at potentially high risk of hamstring injury, focusing on the thigh and shank movement, would be an interesting direction to pursue.

It is worth noting that the improvement in trunk angulation observed in the present study is beneficial for hamstring injury prevention overall. As hamstring stretching is primarily caused by simultaneous excessive thigh lifting and excessive forward tilt of the trunk, the observed improvement in trunk angulation suggests a positive impact on hamstring injury prevention. As running speed increases, thigh movement becomes more pronounced, and the trunk plays a crucial role in controlling hamstring stretching. Therefore, even though there were no significant changes in thigh and shank angles in the present study, the overall improvement in trunk angulation is a positive outcome for hamstring injury prevention. It suggests that modifying trunk posture during sprinting can have a substantial impact on reducing the strain on the hamstrings. Since the thigh and shank segments improved in 6-week training interventions (Mendiguchia et al., 2022), it is likely that more time is needed to improve the thigh and shank segment movement and running performance.

The practical implication of this study finding is that athletes who exhibit concerns regarding trunk angle can be provided with specific interventions (i.e., sprint training intervention) just before a game to mitigate the risk of a hamstring injury. Since the time for intervention immediately before a game is limited, short-term interventions such as the one used in this study can still be effective in correcting movement patterns if there are concerns about trunk movement. While the long-term persistence of the intervention effects is something to consider, the effectiveness of short-term training could be emphasised. Further research could explore the duration of the intervention effects and provide additional evidence supporting the effectiveness of short-term training interventions.

There are some limitations associated with the present study. Firstly, the absence of a control group limits the ability to make direct comparisons and draw conclusions about the specific effects of sprint training.

Including a control group would have allowed for a better understanding of the acute effects of sprint training by comparing the changes observed in the intervention group to a group that did not undergo the training. This would have provided a clearer picture of the specific effects of the training program. However, the results of the present study are robust in terms of generalizability due to the medium sample size. Secondly, the subjects did not have a history of hamstring injury. In the present study, a larger acute effect of sprint training was observed for subjects who have a potentially high risk for trunk posture. Therefore, the acute effects of sprint training on subjects with a history of hamstring injury should be clearer. Future research will more robustly demonstrate the effectiveness of sprint training for hamstring injury prevention when these issues are considered. Even with these limitations, it can be emphasised that there was an acute effect of sprint training on athletes without a history of hamstring injury.

CONCLUSION

We aimed to clarify the acute effects of sprint training on preventing hamstring injury in soccer players. A short-term sprint training program aimed at injury prevention was implemented in 27 male collegiate soccer players. The results of the present study suggest that sprint training has an acute effect on maintaining an upright posture during a sprint without decreasing running speed.

AUTHOR CONTRIBUTIONS

Conceptualization: R. Iwasaki. Data curation: R. Iwasaki. Formal analysis: R. Iwasaki. Investigation: R. Iwasaki, N. Takahashi. and H. Shinkai. Methodology: R. Iwasaki and H. Shinkai. Project administration: R. Iwasaki. and H. Shinkai. Resources: R. Iwasaki. N. Takahashi. And H. Shinkai. Software: R. Iwasaki. and H. Shinkai. Supervision: H. Shinkai. Visualization: R. Iwasaki. Writing - original draft preparation: R. Iwasaki. Writing - review and editing: N. Takahashi. and H. Shinkai.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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ORIGINAL ARTICLE

Emotional states, achievement goals, and performance in NCAA Division I swimmers

Joshua A. Wilt . *Case Western Reserve University. United States of America.*
Shelby E. Johnson. *Mayo Clinic. United States of America.*

ABSTRACT

There is much interest in how emotions and achievement goals predict sports performance, yet little research has examined these topics in elite swimmers. This study involving NCAA Division 1 swimmers aimed to (a) present descriptive information on emotions and goals related to training and meets and (b) predict performance from emotions and 2 x 2 (performance-mastery x approach-avoidance) achievement goals. Over the course of five meets, 13 swimmers (4 men, 9 women) completed weekly ratings of bipolar emotional dimensions (e.g., sluggish-energetic) and achievement goals regarding their training. One day prior to meets, swimmers rated the same emotions and goals regarding the upcoming meet. Event performance was recorded in standardized FINA points. Swimmers (a) experienced neutral emotions (close to the midpoint of bipolar scales) regarding training and positive emotions about meets and (b) endorsed high levels of approach goals and moderate levels of avoidance goals. Correlational analyses revealed that positive emotions associated positively with approach goals and negatively with mastery-avoidance goals. Multilevel models predicting performance from emotions and goals showed sparse associations, with some evidence indicating that increases in energy and decreases in performance avoidance goals prior to a meet related to better performance. We discuss the implications of these findings.

Keywords: Physical activity psychology, Swimming, Emotions, Energy, 2 x 2 goals, FINA points, Coaching applications.

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Corresponding author. *Case Western Reserve University. United States of America.*
E-mail: joshua.wilt@case.edu
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INTRODUCTION

There is great interest in studying how emotions and goals predict sports performance (e.g., Conroy & Hyde, 2011; Hanin, 2000). Despite swimming's high popularity among athletes and fans (National Sporting Goods Association, 2020), there is a limited body of research on emotional and goal predictors of elite swimming performance (Burton, 1988, 1989; Sorrentino & Sheppard, 1978). The current study involving NCAA Division I swimmers assessed emotion on several dimensions and assessed goals from the 2 (approach vs. avoidance) x 2 (performance vs. mastery) achievement goal framework (Elliot & Thrash, 2002) across several intercollegiate swim meets. We explored whether emotions and achievement goals predicted performance.

Emotions and sports performance

Research on emotion and sports performance has focused predominantly on anxiety, with meta-analyses across multiple sports showing that performance is predicted inconsistently and weakly by cognitive anxiety and somatic anxiety (Craft et al., 2003; Woodman & Hardy, 2003). For swimming in particular, one study (Burton, 1988) found a negative association between performance and cognitive anxiety, and a negative curvilinear relationship (i.e., best performance at moderate levels, worse at more extreme levels) between performance and somatic anxiety. An early meta-analysis (Beedie et al., 2000) and more recent, individual studies (Lane et al., 2010; Nicholls et al., 2012) have examined various emotions across many sports, with results generally showing that performance related positively to positive emotions and negatively to negative emotions. The current study assessed emotions on several bipolar dimensions (e.g., calm-tense, relaxed-energetic, pleasant-unpleasant) to cover a range of positive and negative emotions studied in relation to sports performance.

Achievement goals and sports performance

The 2 x 2 framework for achievement goals (Elliot & Church, 1997) is the dominant theoretical framework for studying goals in sports psychology research (Conroy & Hyde, 2011) and was employed in the current study. This framework distinguishes between two definitions of competence (mastery vs. performance) and two valences (approach vs. avoidance), resulting in four distinct goals: Mastery-approach (MAp; striving to improve absolute competence), Mastery-avoidance (MAv; striving not to have a decline in absolute competence), performance-approach (PAp; striving to improve performance relative to others), and performance-avoidance (PAv; striving not to have a decline in performance relative to others). Meta-analyses showed small-to-moderate, positive effect sizes for MAp and PAp goals on performance, and nonsignificant effect sizes for MAv and PAv goals (Lochbaum & Gottardy, 2015; Van Yperen et al., 2014). Although no studies have examined 2 x 2 goals in relation to swimming performance, some evidence indicates that lower swimming performance relates to motivation to avoid failure (Sorrentino & Sheppard, 1978) and focusing on race outcomes rather than personal performance (Burton, 1989).

Overview of the current study

In an experience sampling design, swimmers rated emotions and goals repeatedly over time and competed in five meets. One set of emotion/goal ratings focused on training (completed each Sunday during the season), and another set of ratings focused on competitive meets (completed the day prior to each meet). Because little research has been done on emotions and goals in swimmers, basic descriptive information on these variables was of interest. Descriptive statistics may give insight into (a) the typical emotional and goal profiles of swimmers during a competitive season, (b) the degree of variation in emotions and goals, and (c) covariations among variables. Obtaining ratings of emotions and goals together allowed for examining unique effects (statistically controlling for shared variance) on performance, which is potentially important because emotional and goal states are correlated in sporting contexts (Kavussanu et al., 2014). Based on previous

findings, we expected that performance would associate positively with positive poles of emotion variables as well as MAp and PAp goals. Research on MAv and PAv goals was inconclusive, so we did not make predictions regarding those goals.

METHOD

Participants and procedure

Participants were 13 (4 men, 9 women) swimmers of the NCAA Division I [Anonymized] University Swimming and Diving team. Ages ranged from 18 to 21. Self-reported ethnicities included "*White*" (*n* = 11), "*Multiracial*" (*n* = 1), and "*Some other race*" (*n* = 1). Swimmers were recruited by the second author (anonymized), who was a member of the swim team. Each swimmer generated a unique code name to anonymize data. Over five meets, swimmers completed multiple ratings of their emotions and achievement goals on two paper-and-pencil surveys: (a) a weekly survey given each Sunday, and (b) a meetly survey given each day prior to a meet. Performance times for individual events at four dual meets and one mid-season invitational were recorded. All procedures were approved by the [University] IRB.

Measures

Emotional states

On the weekly survey, swimmers responded to questions about their emotions regarding the "*previous week of training*" on 7-point, bipolar scales: e.g., "*How (e.g., sluggish-energetic) did you feel over the previous week?*" Emotional dimensions were sluggish-energetic, tense-calm, gloomy-cheerful, unsure-confident, defeated-dominant, and unpleasant-pleasant. These dimensions are reflected in prominent taxonomies of emotions (Russell, 1980; Thayer, 1978), with the exception of "*defeated-dominant*," which was recommended by the second author because it was common parlance among the participants. On the meetly survey, swimmers rated the same dimensions with respect to the next day's meet: e.g., "*How sluggish-energetic do you feel when you think about the upcoming meet?*"

Achievement goals

On the weekly survey, swimmers rated their achievement goals on a shortened version of the Achievement Goals Questionnaire for Sport (AGQ-S, Conroy et al., 2003) regarding the upcoming week of training ("*Please respond to each of the following items in terms of how accurate it is for you with respect to the next week of training.*") on a 7-point scale (1 = not at all accurate, 7 = completely accurate). The original version includes three items for each type of goal: PAp (e.g., "*It is important for me to perform better than others in my group*"), PAv (e.g., "*I just want to avoid performing worse than others in my group*"), MAp ("*I want to perform as well as it is possible for me to perform*"), and MAv ("*I'm concerned that I may not perform as well as I can*"). To reduce participant burden, we dropped items with the lowest loading on each factor in the scale development article (Conroy et al., 2003). On the meetly survey, swimmers rated their achievement goals with respect to the upcoming meet ("*Please respond to each of the following items in terms of how accurate it is for you with respect to your next meet*") on one item per goal from the AGQ-S (the example items listed for the weekly questionnaire).

Event performance

The team's HY-TEK Meet Manager system recorded event times. Times were converted to FINA (International Swimming Federation) points on a scale from 1 to 1,100 to allow comparison of performances across events (e.g., 100m freestyle, 200m fly). Prior to the season, swimmers' personal best times for each event were recorded and converted to FINA points.

RESULTS

Descriptive statistics

We used the base commands and the *psych* package (Revelle, 2022) in R (R Core Team, 2023) to compute descriptive statistics aggregated per swimmer (Table 1). The response rate was good for weekly questionnaires (around 90%) and fair for meetly questionnaires (around 60%). The typical swimmer (a) felt neutral (close to the midpoint of bipolar scales) about weekly training and slightly positive about the upcoming meet, and (b) showed high levels of approach goals and moderate levels of avoidance goals. Emotions and goals showed high levels of within-person variation with the exception of approach goals (especially weekly PAp and meetly MAp). The proportion of variance attributable to within-person variation was high except for performance goals. The typical swimmer competed in just over 11 events (average of just over 2 per meet). As would be expected, best previous performance was high relative to typical event performance. Most variation in performance was at the within-person level relative to the between-person level.

Table 1. Descriptive statistics.

	Weekly				Meetly			
	Average *n* per swimmer	*M*	WP *SD*	1-*ICC1*	Average *n* per swimmer	*M*	WP *SD*	1-*ICC1*
Emotion								
Sluggish-energetic	4.6	3.73	1.27	.80	3.0	4.62	1.10	.80
Tense-calm	4.6	3.73	1.48	.91	3.1	4.40	1.07	.92
Gloomy-cheerful	4.6	4.21	1.11	.83	3.0	5.01	1.00	.91
Unsure-confident	4.6	4.09	1.18	.74	3.1	4.64	1.11	.65
Defeated-dominant	4.6	3.96	1.13	.70	3.1	4.84	0.93	.77
Unpleasant-pleasant	4.6	4.24	1.13	.91	3.1	4.95	0.95	.80
Goal								
PAp	4.6	6.67	0.27	.17	3.1	5.42	0.58	.32
PAv	4.6	4.55	0.95	.22	3.1	3.82	0.86	.26
MAp	4.6	5.18	0.58	.56	3.1	6.87	0.20	.97
MAv	4.6	4.04	0.67	.81	3.1	4.49	1.08	.85
Performance								
Event	--	--	--	--	11.6	724.00	51.38	.71
Best	--	--	--	--	11.4	794.02	60.85	.74

Note. Emotions and goals were measured on 7-point scales (1 to 7). The possible range for performance variables was 1-1,100 points. M = average item mean for the typical participant, WP SD = pooled within-person standard deviation. The ICC1 was subtracted from 1 to show the proportion of total variance attributable to within-person variance.

Associations among emotions and achievement goals

We used the statsBy command in the *psych* package to compute pooled within-person correlations between emotions and goals (Table 2). Emotion variables correlated positively with each other on both questionnaires (excepting the correlation between tense-calm and unpleasant-pleasant on the meetly questionnaire), indicating that, for the typical swimmer, increases in positivity on one emotional dimension associated with increases in positivity on all other dimensions (because emotional dimensions were bipolar, these results also mean that increases in negativity on one dimension associated with increases in negativity on all other dimensions). Correlations among goals at the weekly level showed that PAv associated positively with PAp and MAv, whereas no goal dimensions correlated reliably at the meetly level. Correlations between emotions and goals showed that increases in positive emotions generally related positively to MAp at the meetly level

and negatively to MAv at the weekly and meetly levels. Increases in energy and dominance related positively to PAp at the meetly level.

Table 2. Pooled within-person correlations.

Variable number	1	2	3	4	5	6	7	8	9	10
Emotions										
Sluggish-energetic	--	.23	.74	.67	.67	.72	.36	-.03	.46	-.17
Tense-calm	.40	--	.21	.29	.29	.08	.10	.04	.14	-.11
Gloomy-cheerful	.70	.57	--	.67	.73	.78	.09	-.14	.43	-.39
Unsure-confident	.66	.46	.76	--	.56	.62	.20	.03	.37	-.44
Defeated-dominant	.61	.46	.73	.67	--	.59	.31	-.08	.23	-.34
Unpleasant-pleasant	.64	.52	.78	.74	.69	--	.01	-.13	.27	-.21
Goals										
PAp	.07	.11	.06	.09	.00	.07	--	.24	.23	.00
PAv	.00	.07	.05	.03	.09	-.03	.26	--	.22	.04
MAp	.19	-.05	.06	-.03	.22	.00	-.04	.02	--	-.22
MAv	-.24	.14	-.28	-.35	-.27	-.33	.13	.38	-.02	--

Note. Correlations below the diagonal are among weekly variables (rs > |.25| have p-values < .05); correlations above the diagonal are among meetly variables (rs > |.30| have p-values < .05).

Multilevel models predicting performance

Our data had a multilevel structure, with emotions, goals, and performance variables (Level 1) nested within swimmers (Level 2). We computed restricted maximum likelihood (REML) multilevel models (MLMs) using the package lme4 (Bates et al., 2015). The REML estimator produces accurate estimates in two-level models with relatively small samples (Hox & McNeish, 2020; McNeish & Stapleton, 2016), including our sample size of 13 level 2 units (swimmers) with an average of just over 11 level 1 units (meets). We used random intercept models, allowing the outcome variable (event performance) to differ across swimmers. Slopes relating predictors (emotions, goals, and best performance) to event performance were fixed across swimmers. Predictors were person-mean centred, facilitating interpretation of coefficients as deviations from a person's average level.

We conducted a set of three MLMs for weekly and meetly variables separately (six MLMs in all): one MLM predicting event performance from emotions simultaneously, a second from goals simultaneously, and a third from emotions and goals simultaneously. Every event performance time was matched with weekly and meetly emotion and goal ratings (e.g., if a swimmer completed two events in one meet, we matched individual weekly and meetly predictor ratings to both performance times). We entered best performance as predictor in all models to statistically control for swimming ability in a particular race. Unstandardized *b* coefficients indicate the amount of change in FINA points for each 1-point increase in each predictor.

No weekly emotions or goals predicted event performance, indicating that within-person variations in performance were not a function of emotions about the prior week of training nor goals for training during the meet week. For meetly variables, sluggish-energetic related positively to event performance, indicating that within-person increases in performance related to increases in energy about the meet during the day prior to competition. PAv goals related negatively to event performance in the MLM controlling for other goals but were unrelated to event performance in the MLM controlling for goals and emotions. Best performance related positively to event performance in all models.

Table 3. Results from simultaneous multilevel models predicting performance.

Weekly Models						
Model	1		2		3	
Predictors	*b*	*p*	*b*	*p*	*b*	*p*
Sluggish-energetic	-1.22	.85			0.13	.98
Tense-calm	5.02	.26			6.36	.21
Gloomy-cheerful	-3.54	.73			-13.12	.29
Unsure-confident	-12.20	.28			-11.78	.34
Defeated-dominant	9.08	.21			10.91	.14
Unpleasant-pleasant	-1.69	.82			-2.19	.77
PAp			-7.76	.43	-17.08	.14
PAv			9.28	.31	14.70	.15
MAp			-10.27	.49	-10.63	.52
MAv			-5.63	.35	-7.30	.30
Best performance	0.58	< .001	0.59	< .001	0.61	< .001
Meetly Models						
Model	1		2		3	
Predictors	*b*	*p*	*b*	*p*	*b*	*p*
Sluggish-energetic	14.0	.04	--	--	16.60	.04
Tense-calm	-5.40	.25	--	--	-5.80	.23
Gloomy-cheerful	-8.20	.34	--	--	-8.30	.39
Unsure-confident	-5.00	.52	--	--	-2.90	.76
Defeated-dominant	-4.00	.67	--	--	-4.70	.68
Unpleasant-pleasant	4.50	.64	--	--	-1.00	.93
PAp	--	--	-0.67	.93	-2.40	.80
PAv	--	--	-13.23	.04	-8.80	.20
MAp	--	--	-3.28	.86	-11.90	.61
MAv	--	--	-0.38	.93	-3.90	.42
Best performance	0.50	< .001	0.43	< .001	.46	< .001

Note. Model 1s entered all emotions and Best Performance simultaneously; Model 2s entered all goals and Best Performance simultaneously; Model 3s entered all variables simultaneously.

DISCUSSION AND CONCLUSIONS

This study yielded novel descriptive and correlational data regarding Division I swimmers' emotions and goals over the course of a competitive season. These results may be useful for swimmers and coaches, as we discuss in the Emotions and Motivation During a Competitive Season section below.

Regarding performance, results were mostly inconsistent with our hypothesis that positive emotions would relate to swimming performance, as only energy about the next day's meet positively predicted performance. Results also did not support our hypothesis that approach goals would positively predict performance, as only increases in PAv goals about the next day's meet negatively predicted performance uniquely from other goals. One potential reason that we did not uncover more associations with performance is because we had limited power to detect small effects. We were able to detect several moderate to large effect sizes in within-person correlations between goals and affect.

We believe that the findings for performance, though sparse, may have important practical implications. Increases in individual (and thus team) performance may be related to increases in feeling energetic as opposed to sluggish, as well as to decreases in PAv goals, about the next day's meet. These findings complement research showing that more negative emotional and motivational states related negatively to swimming performance (Burton, 1988, 1989; Sorrentino & Sheppard, 1978). Thus, elite swimmers may benefit from finding ways to be in a more energetic emotional state and less performance-avoidant frame of mind. Swimming coaches may also consider encouraging thinking and goal-setting strategies aligned with these emotional and motivational states.

Emotions and motivation during a competitive season

Due to the limited amount of research in elite swimmers examining emotions and achievement goals, descriptive data and correlations were also of interest. On average, swimmers felt mostly neutral (close to the midpoint of bipolar scales) about weekly training and relatively positive about meets. There was substantial within-person variation in all emotions, and variations toward positivity were correlated across all emotional dimensions. Thus, swimmers' emotional experience included various highs and lows over the season, with general increases in positivity around meets. It may benefit coaches/swimmers to know that this is how swimmers feel in general over the course of a season. Coaches/swimmers need not be alarmed by slight variations in positivity and negativity, as they are likely not a sign of abnormality. Coaches might want to anticipate and capitalize on the increased positivity leading up to meets. This could be an opportunity to engage with swimmers when they feel most positive, potentially increasing energy, which might result in benefits to performance as discussed previously.

For achievement goals, across the weekly and meetly measures, swimmers generally showed high levels of PAp and MAp goals (with low levels of within-person variation). Therefore, swimmers were nearly always highly motivated to do better than others and increase performance relative to themselves, which may be expected amongst swimmers at an elite and highly competitive level. Coaches may want to reinforce these normative goals and be on the lookout for swimmers who do not have high levels of these goals, as that could indicate that motivation is lacking. Swimmers may benefit from self-monitoring approach goals and seek help if approach motivation is low. Swimmers showed moderate levels of PAv and MAv goals, as well as substantial within-person variation and positive correlations at the weekly level among these goals. These findings indicate that swimmers were moderately concerned about doing worse than others and that their competence would decrease, and these concerns tended to go together across weeks of training. Thus, concerns about doing poorly may emerge at different points during the season, but such concerns do not seem to be as salient as increasing performance levels. Coaches may expect that concerns about doing poorly may emerge at different points during the season and thus may want to devise strategies for helping swimmers to realign with more positive goals if they trend toward more avoidant goals. Swimmers also need not be alarmed or distressed by avoidance goals but work with their coaches to determine the reasons for avoidance motivation and collaborate on strategies to decrease these kinds of goals.

Turning to correlations between goals and emotions, PAp and MAp goals related positively to multiple positive emotions at the meetly level, indicating that swimmers felt better about their upcoming meet when their motivation to do better than others and increase their competence was higher. Weekly and meetly MAv goals related negatively to positive emotions, indicating that swimmers generally felt worse when they were more concerned about their own competence decreasing. These findings are in line with a broad collection of research showing that approach goals tend to relate to positive emotions and that avoidance goals tend to relate to negative emotions (Goetz et al., 2016) and add to the limited work looking at relations among achievement goals and emotions in athletes (e.g., Kavussanu et al., 2014). Coaches may use this information

to potentially generate more positive emotions in swimmers. Coaches might want to educate swimmers about the emotional benefits of PAp and MAp goals, as well as the emotional deficits of MAv goals. Further, coaches could help swimmers to articulate of PAp and MAp goals rather than MAv goals.

Regarding limitations, we reiterate that our findings are limited by our small sample size; however, as this study was exploratory in nature and examined under-researched topics, the data represent a promising starting point for larger-scale studies on emotions, achievement goals, and performance in elite swimmers. A second limitation is our use of single items to assess constructs and removing items from the AGQ-S (Conroy et al., 2003), both done for the sake of reducing participant burden in a sample that was likely to be extremely busy. These features may have decreased the reliability and narrowed the scope of our measures, and therefore future studies may attempt to use more comprehensive when doing so would not be onerous to participants. Third, the study is limited by the timeframes we chose for assessment (weekly, the day before each meet); findings may have differed if we conducted assessments at different times (e.g., the day of the meet, minutes before the meet) or with different frequencies (e.g., multiple times per week or per day). Fourth, self-reports have well-known limitations that apply to our self-ratings of emotions and goals, and thus alternative assessment strategies (e.g., behavioural, physiological) are encouraged in future work. Finally, it is worth noting that we cannot make strong conclusions about causality from correlational data, and experimental studies manipulating emotions and achievement goals would be needed to do so.

AUTHOR CONTRIBUTIONS

Conceptualization: Joshua Wilt and Shelby Johnson. Methodology: Joshua Wilt and Shelby Johnson. Software: Joshua Wilt. Validation: Joshua Wilt. Formal analysis: Joshua Wilt. Investigation: Joshua Wilt and Shelby Johnson. Resources: Joshua Wilt and Shelby Johnson. Data curation: Joshua Wilt. Writing –original draft preparation: Joshua Wilt. Writing – review and editing: Joshua Wilt and Shelby Johnson.

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ORIGINAL ARTICLE

Body size, race, and beauty in sport: A preliminary study of the perspectives of a university's female rugby and netball players

Maria Lucia. *Exercise, Sport and Rehabilitative Therapies. School of Nursing and Health Sciences. University of Sunderland. Sunderland, United Kingdom.*
Paul Davis . *Exercise, Sport and Rehabilitative Therapies. School of Nursing and Health Sciences. University of Sunderland. Sunderland, United Kingdom.*
Ian Whyte. *International Network of Sport and Health Sciences. Nancy, France.*

ABSTRACT

This study investigated the attitudes of female university rugby and netball players toward their bodies, specifically their perceptions of size, race, and beauty. The sports were chosen because of their respective masculine and feminine images, historically. The study used a qualitative design. Semi-structured interviews were conducted with a sample of eight players from the women's rugby and netball teams at a university in the north-east of England. Thematic analysis revealed three themes: inclusivity, discrimination, and the promotion of inclusiveness. Almost all participants reported negative body image, especially outside the sporting environment. However, most participants emphasised a positive outlook on their bodies in society and on the utilisation of their unique bodies to better serve their purposes in the sports they play. The study's findings emphasise the need to foster inclusivity of body types and races in sporting environments and in the rest of society.

Keywords: Physical activity psychology, Body image, Self-image, Thematic analysis, Society, Sport performance.

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Corresponding author. *Exercise, Sport and Rehabilitative Therapies. School of Nursing and Health Sciences. University of Sunderland. Sunderland, United Kingdom.*
E-mail: paul.davis@sunderland.ac.uk
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INTRODUCTION

Sport is a massive social and cultural phenomenon. Beedie and Craig (2011) note that sport is, globally, a frequent component of people's lives. Sport is therefore fitted to contribute to our understanding of and response to social and cultural problems (Sekot, 2009). While a site of self-expression, humanisation, and identity-performance (Kretchmar, 2015), sport has been available to some more than others. One cause of limited availability is gender inequality.

While gender inequality extends far beyond sport (Senne, 2016), sport is a site of precise manifestations. For instance, women and girls have suffered and continue to suffer exclusion, under-payment, and undervaluation. Molnar and Kelly (2013, 169-170) observe that 'men still have more and wider opportunities to turn professional and make a living out of practicing and performing', and offer the illustration of bodybuilder Joanna Thomas, unable to secure sponsorship and moved to provide nude pictures of herself on the internet for paying customers to supplement her income (for some expose of how the Covid pandemic threw gendered material inequalities in sport into sharp relief, see Davis and Weaving, 2022). Males have long dominated the structure of sport too, from performance and prestige to organisation, officiating and coaching.

Gendered material inequalities in sport cannot be detached from the symbolic inequalities and historical ideologies to which they are intimately connected. Russell (2002) observes that women's involvement in physical exercise during the nineteenth and early twentieth centuries sparked a variety of anxieties, worries and false beliefs about negative repercussions, underpinned by and recreating the 'frailty myth'. Leong (2018), similarly, notes that until 1870 women's participation in sport was viewed as purely recreational rather than a means of competition. Female physical education pioneer Madame Osterberg, again, saw the value of female physical education as its contribution to the creation of successful mothers and homemakers (Hargreaves, 1994, 77-78). This landscape provides early intimation of the symbiosis of sport and masculine attributes such as power, aggression, strength, dominance, and violence (Hardy, 2015) - desiderata of 'hegemonic masculinity' (Connell, 1987). The prototypical sport body, again, has been conceived as an 'able-bodied' *male* body, defined by a height, weight, muscle mass, toughness, and athleticism more likely to be found in men (Lunde and Gattario, 2017). This echoes Willis's (1994, 36) observation that 'it is assumed that sports success *is* success at being masculine. Physical achievement and masculine identity are taken to be the same.' The matrix of sport, sporting bodies and masculinity is sufficient to make female sport a diminutive version, a status confirmed by the fact that males, again, have dominated sport's scaffolding, such as organisation, officiating, and coaching. Furthermore, a prestigious conception of femininity, defined by (among other things) bodily *passivity*, has encouraged the notion that sport – especially that centralising speed, strength, and power – and femininity are antithetical (Mackinnon, 1987, 120). As Willis (1994, 36) again puts it, 'to succeed as an athlete can be to fail as a woman, because she has, in certain profound symbolic ways, become a man.' And the unkindest cut of all might be that even in sports (such as figure skating) culturally identified with girls and young women, success is to do with 'fitting the youthful, lithe, nubile, stereotypically "*perfect*" popular image of femininity' (Willis 1994, 36). This is illustrated in Daddario's (1994) study, which found that a major American media network's coverage of women's events at the 1992 Winter Olympics featured a range of devices foregrounding female athletes' sexual attractiveness or beauty, i.e., their putatively endearing, putatively adolescent, or prepubescent qualities; their mental fragility; and their motivations to please others (such as family members) through their Olympic performance.

The immediately preceding involves (among other things) media behaviour. Pedersen (2002) contends, prior to the advent of social media, that one of the most significant influences upon contemporary gender attitudes is the media. Writing over a decade later, Trolan (2013) observes that the mass media plays a significant

role, through daily images in print and television, in spreading gender discrimination and gender inequalities. There is, again, a preoccupation with what a woman's body should look like, as a criterion of whether she is worthy of participation in sport (Trolan, 2013). Fink (2015) similarly observes that characteristics such femininity and heterosexuality continue to dominate how the media frames sportswomen, echoing Lock's (2010) invocation of Butler's notion of the 'heterosexual matrix', linking sex, gender, and female heterosexuality. In cahoots with these framings is a media idealisation of female thinness (Greenwood and Cin, 2012) and whiteness. Media body ideals are typically embodied in white women (Greenwood and Cin, 2012). Greenwood and Cin (2012), again, observe a regular social assumption that people of colour belong to another cultural environment, in which the white, thin beauty ideal is rejected or considered irrelevant, and where determinants of female self-esteem are more likely to be community and (non-media) institutions such as religion.

The preceding landscape courts body image challenges for females who play sport. These challenges might be nuanced according to features such as the sport played, whether one is inside or outside of one's sport environment, and race.

Rugby and netball are, materially and culturally, very different sports. The first is a sociocultural signifier of masculinity, while the second is a sociocultural signifier of femininity. Rugby is seen as a sport for men because of how physically demanding the game is (Kane and Snyder, 1989). Like football and hockey, it encourages and celebrates the traditional masculine notions of dominance through forceful physical contact and toughness (Hardy, 2015). Female rugby has therefore been hindered by the fear that women may become more masculine (Joncheray and Tlili, 2013). Netball, in contrast, is a sport in which women predominate and is a successful female sport (Nauright and Broomhall, 1994). However, this success is not without ambiguity. In the late nineteenth century, women's basketball led to netball to match patriarchal notions of 'an acquiescent femininity' (Devonport et al., 2019). Basketball's contact was eliminated, which Treagus (2005) described as a process of diminishing basketball's masculinity to make sure it complied with the prevalent conceptions of female physical movement. The limited exertion and absence of contact make netball a female sport acceptable to the patriarchal environment of sport. Furthermore, netball is notable for fostering femininity in its participants' attire, body, and behaviour (Devonport et al., 2019).

Women's sport has made undoubted progress. Women are quickly making their way into sports once thought to be for exclusively male participation (O'Neill and Mulready, 2015). Despite this, there remain problems with the potential to impact on how female athletes see their bodies (Varnes et al., 2013). Historical and contemporary societies apply beauty standards that call for a slim, athletic body type that is difficult to attain. Female athletes, again, are vulnerable to framing as sexual objects. This co-exists with pressure to achieve excellence in one's sport (Godoy-Izquierdo and D´ıaz, 2021).

There is evidence that female athletes have good body perception in the sport context (see Liechty et al., 2015; Lunde and Gattario, 2017; Devonport et al., 2019, as cited in Godoy-Izquierdo and D´ıaz, 2021). Despite the social negativity surrounding female athlete body image, female athletes adopt 'body positivity'. This involves improvement in body image through appreciation of physical changes, and a greater understanding and appreciation of the utility – as opposed to the appearance - of one's body. The female athlete honours and celebrates her body because she is united with it in a loving and appreciating way (Godoy-Izquierdo and D´ıaz, 2021).

Outside of the sport context, however, female athletes might worry about their actual and 'ideal' body weight, size, and form, since they often do not fit the stereotype of the typical female body. Female body ideals,

again, elevate the slim, white, curved, toned and heterosexual body. Women who play male-dominated sports, such as football, rugby, and hockey, must deal with the insulting terms, 'butch' and 'lesbian', used to disparage their appearance (Liechty et al., 2015).

Daddario's (1994) foregoing findings reveal problematic commentary on female athletes. Nor is such problematic commentary consigned to the dustbin of history. Despite a drop in openly sexist representation (Wolter, 2021, as cited in LeCouteur and Yong, 2022), male and female athletes are still described differently. For instance, commentators continue to emphasise female athletes' physical attributes above their performance skills (Fink, 2015). Nor is the problematic commentary confined to those whose job it is to commentate. Body commentary often comes from coaches, parents, athletes, friends, and other spectators (LeCouteur and Yong, 2022; Muscat and Long, 2008; Slater and Tiggemann, 2011). Athletes who hear harsh criticism of their bodies, especially from coaches, may become upset and anxious, because they feel under pressure to meet specific standards of appearance (Mosewich et al., 2009). Ryan (1996, cited in Muscat and Long, 2008) illustrates in the case of gymnastics coach Bela Karolyi (male) how coaches' (overwhelmingly male) negative remarks propagate the sociocultural value of beauty, slimness and (therefore) weight loss: Karolyi called one pupil a 'pregnant cow' as she began puberty, called another a 'pregnant spider' and called another an 'overstuffed Christmas turkey'. Kerr, Berman, and Souza (2006), again, find that coaches frequently make comments about teen girls who grow hips or breasts. This behaviour may damage a young woman's body image and may cause her to wonder what is going to happen to her body.

The objectification theory (Fredrickson and Roberts, 1997) is another lens through which to view body image in women's sports. Based on this theory, women are valued more as objects to be used and consumed by others than as individuals with emotions and distinct purposes (Muscat and Long, 2008). According to Fredrickson and Roberts (1997), the objectification theory explains how being a woman in over-sexualized Western cultures will significantly affect one's life. It explains that after seeing various forms of bodily objectification, women and girls eventually start to view themselves as an 'object' that people can judge, based solely on their appearance (Prichard and Tiggemann, 2005). Fredrickson and Roberts (1997) introduced the term, 'self-objectification', which signifies a constant close eye on one's appearance. Though not all women experience it, most self-objectification is associated with negative outcomes. It depends solely on how a person views their body. For instance, ballet dancers have been identified as at risk of self-objectification and eating disorders, due to their high concentration on their bodies and appearance (Prichard and Tiggemann, 2005).

Research has now shifted its emphasis to how external factors lead to objectification and therefore how to lessen it (Liechty et al., 2015). Most physical activity venues (e.g., gyms) highlight someone's attractiveness and weight, which may create an environment that is objectifying (Prichard and Tiggemann, 2005). D'abundo (2007) explains that physical activity with a focus on health, well-being, and pleasure, rather than appearance, produces less oppressive and objectifying circumstances. A healthier atmosphere could result if people view the physical activity setting as a tool to assist them in their health, rather than something to help them appear fit in today's society. A healthy environment will result in a lower self-objectification and increase the likelihood of positive body image (Liechty et al., 2015).

The significance of race and ethnicity to the ideal body is unclear. Craig (2006) observes that race has commonly been excluded from feminist studies of beauty, despite the intimate ties between racial politics and discourses of beauty. Writing much later, Winter et al. (2019) note that race and ethnicity, which may have an impact on body ideal and self-image, have not yet been sufficiently investigated. However, Winter et al.'s (2019) study found that women of colour have a higher appreciation of their body image. In contrast,

white women are more concerned with their weight and appearance, which can lead to eating disorders and high levels of anxiety or depression. Women of colour choose to embrace their bodies (Mucherah and Frazier, 2013; Winter et al., 2019) and enjoy the uniqueness expressed in smiles, styles, attitudes, and confidence (Winter et al., 2019), limiting the hegemony of white 'thin' culture.

This study seeks to discover the respective body image experiences and impressions, inside and outside of one's sport environment, of members of the female rugby and netball teams at a university in the north-east of England, UK. The research population, again, was selected because of the preceding material and symbolic differences between rugby and netball, which might elicit different body image experiences and impressions. To meet this overarching aim, three research questions (RQ) were developed:

- RQ 1. What are university female rugby and netball players' perspectives upon the value of their bodies?
- RQ 2. What are the similarities and dissimilarities in how university female rugby and netball players perceive and value their bodies?
- RQ 3. How do university female rugby and netball players perceive and value their bodies with respect to societal standards of female attractiveness?

METHOD

Following ethical approval by the host university (Ethics reference number 011937), adult female rugby and netball players from a university in the north-east of England were invited to take part in this study.

This investigation employed a qualitative approach, eliciting data through semi-structured interviews. This allowed the researchers to concentrate on the athletes' experiences, feelings, and the explanations proffered by them for their behaviour or perceptions (Merriam, 2019). Semi-structured interviews also allow for adaptability in questioning, providing the ability to re-order questions or follow-up lines of interest with supplementary questions, resulting in the prospect of gaining richer data (Jones, 2022).

Interviews were conducted online and recorded for transcription using Microsoft Teams (Microsoft Corporation, One Microsoft Way Redmond, Washington, U.S).

Recruitment

Recruitment was a two-stage process. First, two gatekeepers, namely a rugby coach and a netball team captain, were contacted by email. They were sent information about the study, inclusion criteria, and how confidential data would be handled, alongside a request for their assistance in identifying potential participants for the study. The gatekeepers provided details to the researchers, after which they had no further dealings with the project team.

The second stage of the recruitment process involved each prospective participant being sent an email invitation, accompanied by a Participant Information Sheet and an Informed Consent Form. Eight women responded affirmatively, and having completed and given their informed consent, were recruited for the study.

Participants

Four female rugby players (mean age = 19.5 years, range 19 – 20 years) and four female netball players (mean age = 24 years, range 21 – 30 years) took part in the study (Figure 1). Mean age of the eight participants = 21.75 years; SD: ± 3.69. There was a large range of experiences noted, with one netball player citing 25 years of experience, and one rugby player 10 years. Other participants had notably less experience.

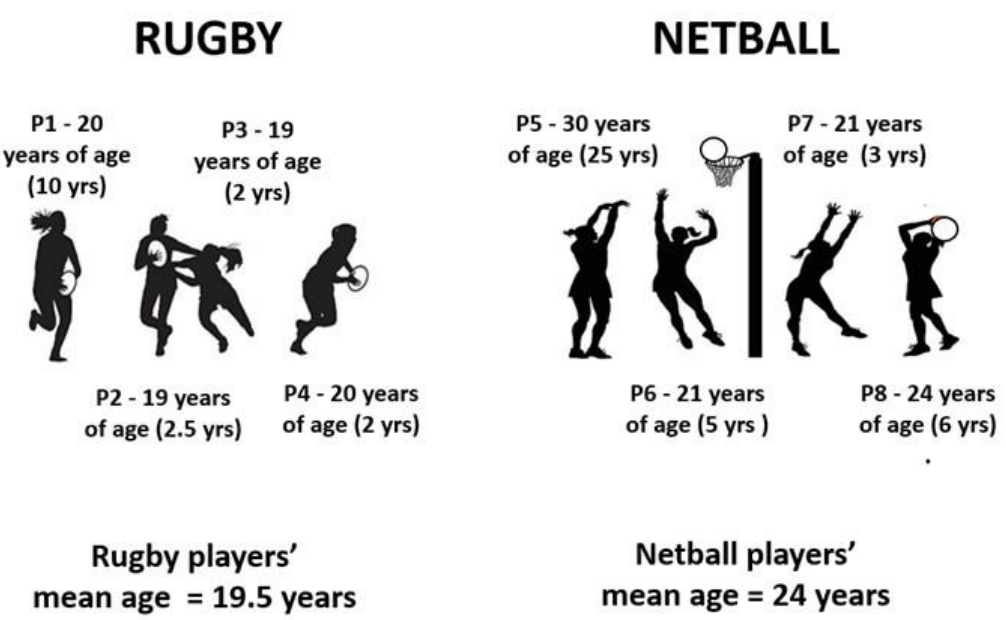

Figure 1. Diagrammatic representation of participants, indicating participant ID (P), age and years' experience (in parentheses).

Data analysis

All interviews were recorded and transcribed *verbatim.* Data was analysed thematically following Braun and Clarke's (2006) six stage process. At the first stage (Read and Take notes), personal identifying information was removed from the text. The process then followed that of similar studies, with meaning units identified, coded, and then allocated to themes that were identified by the authors (Figure 2). A meaning unit has been defined by Tesch (2013, p121) as '… a segment of text that is comprehensible by itself and contains one idea, episode, or piece of information.' In this context, it might be a word or two, a sentence or a bigger chunk of information. Irrespective of length, the determining factor is that a meaning unit must mean something in the context of the research undertaken.

Figure 2. Representation of Braun and Clarke's (2006) 6-stage thematic analysis process.

To help ensure trustworthiness, *member checking* was carried out. Jones (2022, p. 288) explains member checking as asking 'those being investigated to judge the analysis and interpretation themselves, by providing them with a summary of the analysis and asking them to critically comment upon the adequacy of the findings. Participants were sent copies of the analysis, and all were happy with it.

RESULTS

Following *verbatim* transcription of the eight interviews, 25,000 words were presented for thematic analysis. The first stage involved an initial read-through of the text, during which personal identification information

was removed. Next, meaning units were identified and distilled to nine themes. Further analysis developed three main categories with three themes in each category. The categories were Inclusiveness, Discrimination, and Promoting Inclusiveness (Figure 3).

Figure 3. Diagrammatic representation of nine themes identified following coding and the three categories developed from further distillation.

Inclusiveness

Participants provided comments that were distilled into three themes before being grouped under the category of inclusiveness. The themes reflected participants' attitudes toward their own appearance, their views of sociocultural attitudes to appearances, and their perceptions of the attitudes that sport have around appearances (Figure 4).

Figure 4. Inclusiveness and underlying themes that illustrate meaning units.

Inclusive Attitudes to One's Own Appearance

It is recognised that the way in which an individual views or experiences their body (body image) often varies across time and circumstance (Grogan, 2021). Irrespective, a person's body image impacts how that individual value their own body (Grogan, 2021). This can be expressed in positive or negative thoughts or behaviours. Most respondents felt positive perceptions of their bodies increased as they aged and matured. Inclusive statements about their own appearances were common in the transcripts, with most developing the idea that being different should be viewed as a positive characteristic, as it shows uniqueness. For instance, Participant 4 commented on this uniqueness while also recognising that for some, it might be viewed negatively (Figure 4).

Most interviewees suggested that competitive sport participants often had different conceptions of participation from the general population who exercise. For example, competitors are likely to want to improve fitness levels and well-being, as well as their competitive performance, in contrast with the broader 'physically active' population, who tend to have more aesthetic goals (see fuller review in Harwood et al, 2015). Participant 5 exemplified this:

> *I do care what I look like, but I'm doing the Great North Run [half marathon] in September, so I am now running to train for that. I'm not running to lose weight. I'm running to train for that event. So, I think that it is slightly different from people who run to lose weight or become slimmer, or whatever. (Participant 5).*

Other positive messages, mostly affirming the changes in their bodies as they trained and got fitter, were given by both sets of participants. These changes were of concern initially, but the concerns were supplanted by the realisation that it was those self-same bodies that assisted their success in their respective sports. Participant 4 stated:

> *You kind of realise ... your purpose in a rugby match is better served because of my size and because I'm a bit bigger than other people. I'm that stronger. That makes me better at the position that I'm asked to play. (Participant 4).*

Inclusive sociocultural attitudes to appearances

Most participants viewed society's attitudes to body image as problematic. Through time, societal attitudes about body size, race, and appearance have changed. Respondents identified this change even in their relatively young lives. However, they also recognised that societal views about how a person or a group appears can still be stereotypically negative. Participant 2, for instance, indicated concerns about how people perceive and value people of colour (Figure 4).

Participants believed strongly that sport has the capacity to promote greater inclusivity and needs to do so, specifically in showcasing differences in body types, shape and stature, and race. Participant 3 vocalised this concern, focussing on the impact that seeing different types of people taking part in sport makes, through providing diverse positive role models for younger people. The issue of race, colour, and body type was also mentioned by Participant 8, who believed strongly that social media stokes many toxic and damaging images of bodies, especially to young people. She called for broader conceptions of 'ideal' bodies (Figure 4). She expanded on the issue of representation of people of colour:

> *... it really means that you can relate to them and feel validated by them being there and showing up because we know that people of colour are often shunned and often not given the attention they*

deserve or representation they deserve. And it will make a huge difference to people confidence if they can see themselves and people in the media and in sport. (Participant 8).

Inclusive Sport Attitudes to Appearances

When it came to sport-specific attitudes to players' appearances, rugby and rugby players were deemed to have strong perspectives on the value of body type inclusivity. Our rugby respondents all recognised and stated that rugby was a sport for all, irrespective of size, shape, race, or appearance (see Participant 1's comment in Figure 4). She continued her promotion of rugby's diversity image, noting:

You just have to be able to play, really. Just show up to training and ... or like cause different place like different people at different roles. Like you're not great like running a lot, like running distance and like being fast and all, then there's like different positions for you. (Participant 1).

The role that the sport of rugby has in promoting confidence, body-image, and ultimately self-esteem cannot be underplayed. Participant 2 offered her vision of its importance (Figure 4).

By contrast, netball players offered different insights with respect to the importance of body-type in netball. All four were in accord about the need to be tall to play at a high level. Such comments were partly mitigated by Participant 5, who noted that height is imperative at elite standard, but that being shorter should not preclude others from playing at their own levels.

Discrimination

Following analysis of the transcripts, the next category identified was Discrimination. The data highlighted poor body image and its negative consequences. It is organised under three themes: attitudes to one's own appearance; sociocultural attitudes to appearances; and sport attitudes to appearances (Figure 5).

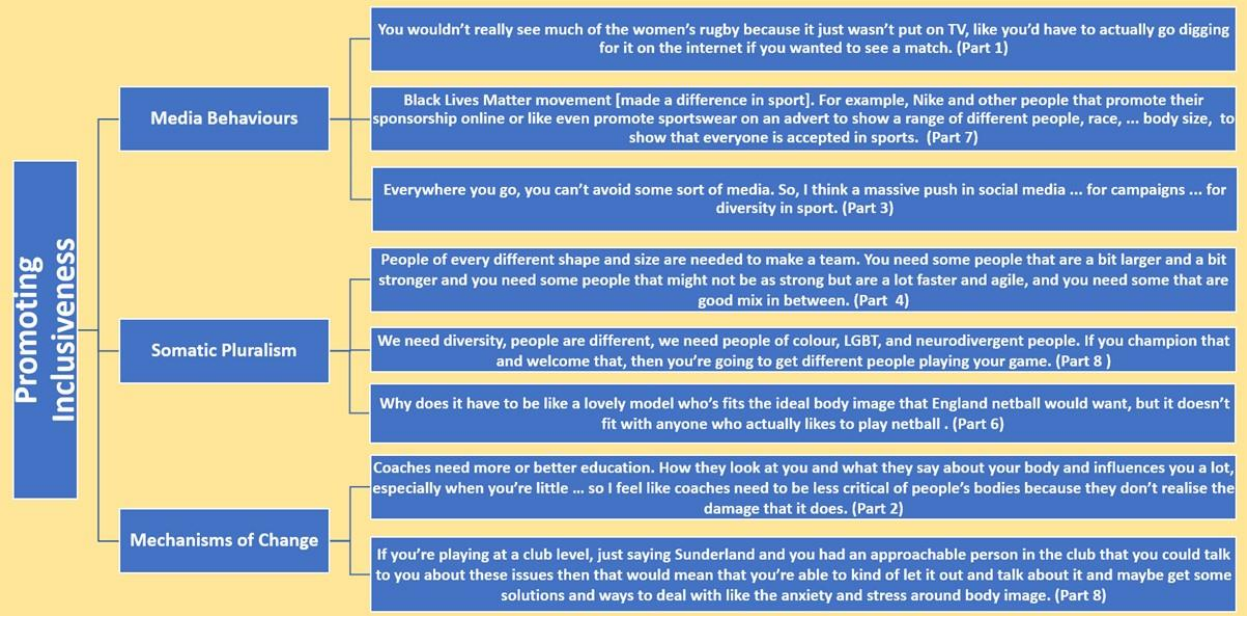

Figure 5. The category of Discrimination and underlying themes showing examples of meaning units.

Discriminatory attitudes to one's own appearance

All participants recounted struggles they had experienced while dealing with their (at times changing) body. They identified that there were different and sometimes ambiguous messages inside and outside of sport (see, for instance, Participant 2, Figure 5).

Continual comparison with others was viewed as a debilitating factor, with some respondents confirming that such comparisons were made between their athletic bodies and non-athletic bodies of general society.

Society's 'ideal' model was often at odds with more muscled or defined bodies of sportswomen. Negative consequences were reported, often involving weight-loss or restricted dietary intake. One example is that of a 30-year-old netball player, who related the difficulties she experienced when obsessed with losing weight:

> *I was addicted to it, if you know what I mean. I was recording everything I ate and the calorific values. That was as a result of comparing myself to other people [and wanting to be thinner, like them], not because it meant that I could run faster or play netball better. (Participant 5).*

Discriminatory sociocultural attitudes to appearances

The sport of netball is considered by many to be a feminine sport, with the media and broader sport culture influencing what a netball player should look like (REF). From this has evolved the stereotypical picture of a slim, tall netball player (see Participant 7, Figure 5).

Most comments indicated the negative influence of social media and other outlets in contemporary society, due to their promotion of what the 'ideal' woman should look like. The fickleness of these media was also noted, with Participant 2 (Figure 5), again, indicating contradictions between the promotion of a healthy, fit body and the constant advertising of weight loss products and plans, alongside images of 'ideal bodies':

> *And it's just like, so which would you rather a person be: happy and comfortable whilst they promote other bodies to lose weight and stuff like that. I just don't understand that. It's kind of a mixed messaging. (Participant 2).*

Additionally, social media offers a platform for constant comparison with others, with the potential for negative consequences, especially for younger women. One participant offered further opinions on how social media challenges young girls' perceptions of themselves:

> *I think they [younger girls] are the people that watch social media ... [the impact is] based a lot on their own self-confidence and how they feel about themselves, because you can constantly compare yourself to other people. (Participant 5).*

Discriminatory attitudes in sport to appearances

While social media promotes perceptions of appearances, all of which bring pressure to conform on athletes of all ages and abilities, society in general also advocates on athletes' body type and appearance. This burdens some athletes to match those perceptions (see Participant 4, Figure 5).

Earlier in this text, we explained that netball players were expected to be tall, however, appearance is also deemed to be important:

So, there is a big stigma about how you should look on a netball court and being like tanned, shaved legs, hair ... beautifully done, nails, gorgeous like super slim, super skinny. (Participant 6).

Promoting inclusiveness

This is the final category, with three themes underpinning themes: media behaviours, somatic pluralism, and mechanisms of change (Figure 6).

Media behaviours

Participants highlighted the opportunities for the media to promote inclusion and diversity of body types and appearances. Yet comments emphasised that the contemporary media frequently highlights sports for men, and expressed the impact:

I grew up only watching men's rugby matches on television because that is what was televised. Supporting the men's game is not a problem, but as a woman or a young girl, sometimes you could not relate to men's game or men's representations of body (Participant 1).

Participant 7 advocated that media advertisements display different body types, appearances, and ethnicities. She also observed that the *Black Lives Matter* movement had a positive impact on inclusion and diversity in sport (Figure 6).

Figure 6. The category of Discrimination and underlying themes showing examples of meaning units.

Participants called for media platforms, given their (preceding) ability to promote diverse body types, to promote positive messages (e.g., Participant 3, Figure 6). Participant 3 cautioned, however, that positive messages are not enough:

It's not just saying it [presenting the message], saying 'everyone should play rugby' or 'there's no specific type of person you need to be to play this sport'. You have got to show it as well. (Participant 3).

Somatic pluralism

By 'somatic pluralism', we intend an egalitarianism of (female) body-types. That is, neither the white, slim, curved soma nor any other is privileged. Hierarchy of female bodies (according to slimness or colour, for instance) is rejected. One of the concerns around the 'body ideal' in contemporary society is that it focusses heavily on one demographic, namely white people. This led to a call from participants to promote the right for everyone to be able to take part in sport, as well as be accepted in society, irrespective of appearance and body type. Given that the participants play team sports, they endorsed the need for teams to consist of people of all types. A comment from Participant 4 illustrated this perspective with respect to rugby:

> *You know, if you had a team full of the whole same size, it wouldn't be very good because you need different people with different strengths to deformity, and so I think it's just making that more known and more common in other sports that we don't all have to be the exact same to do this sport. We can have variant of body types because we did need different ... you know, different body types for different factors. (Participant 4).*

Participants believed that sport could champion diversity and inclusion (e.g., Participant 8, Figure 6), continuous with the need for society to accept the uniqueness of individuals. Participant 8 finished by noting how such behaviour could impact on sport:

> *It's just going to completely change the way that sport is looked at if it seems like it's a ... a game and a sport for everyone to take part in. (Participant 8).*

In sport, advertisers often use professional models instead of real sportswomen to demonstrate society's view of athleticism. This was challenged by Participant 6 (Figure 6). Participant 5 voiced her opinions of how such negative imagery might be negated, especially to help younger athletes:

> *I think we should be focusing on that [sportspeople] and pushing [promoting]that young girls and women, as opposed to all of these Instagram models that don't [are not sportswomen or girls]. We don't see behind the scenes, we don't know whether they might have, you know, starved themselves for a week for one set of photos, and you know it's not real life. So, I think we have to look at women that have succeeded in sport and look at them for their sporting ability, not for how they look or base the fact that they've done well on is because of their body shape or whatever. (Participant 5).*

Mechanisms of change

The final theme of this category reflects participants' views of how change might be actioned. Participants all recognised that spectators and coaches make comments about athletes' appearances in training or on the field of play. Participants suggested this might be due to ignorance. Nonetheless, with negative comments affecting athletes' self-confidence and mood, education was proposed as a strategy to counter this:

> *We need to educate coaches and society in general to be more mindful when criticising students' or athletes' appearance, because it could impact the athletes' attitudes towards the sport they love. (Participant 2).*

Participant 2 expanded, focussing on the sway that her coach held with her:

> *When I danced, my coach had a lot of like influence on how I felt about myself. Her views were important to me. (Participant 2).*

In addition to educating society about body commentary, Participant 8 (Figure 6) promoted the need for support, proposing that teams need well-being or welfare officers to monitor and counsel athletes where necessary: '[This would] make sure that they are mentally healthy while playing.

DISCUSSION AND CONCLUSIONS

This study was designed to answer the three research questions (RQ):

- RQ 1. What are university female rugby and netball players' perspectives upon the value of their bodies?
- RQ 2. What are the similarities and dissimilarities in how university female rugby and netball players perceive and value their bodies?
- RQ 3. How do university female rugby and netball players perceive and value their bodies with respect to societal standards of female attractiveness?

In consideration of this section of the paper, it was clear that there is an overlap among participant responses that made it difficult and artificial to focus discretely on each research question. For example, participants' responses suggested that at times they held negative perceptions of body image. This could be aligned with RQ 1. When probed on the grounds for such perceptions, the responses indicated that societal standards played a role. This could be aligned with RQ3. Therefore, this section is presented more discursively and with less hierarchical ordering than is typical. Noted in parentheses are RQs to which the text seems to refer e.g., '(RQ 1)', evidencing that the three research questions have been answered.

In the world of women's sports, body image issues are prevalent (Sabiston et al., 2020; Slater and Tiggemann, 2011). Almost all participants reported positive body images in sporting society or while participating in sports (RQ1). However, some participants expressed concern about the pressure athletes feel to appear in a specific way when they wanted to be female athletes (RQ 1). They especially felt insecure when they began participating in sports. Moreover, everyone who participated in this study felt that sport society needs to be more accepting of the variety of body images, and that everyone should be able to engage in sport, regardless of body size, ethnicity, or appearance (RQ 1).

Most participants found it uncomfortable to respond to questions on ethnicity and ideal bodies. This discomfort might be because of the sensitivity and volatility of issues of race and ethnicity in the present day. Some participants, however, honestly responded to the issue by asserting that there should be multiple body ideals in modern society and that they should not all be tied to the "*white*" ideal body standard (RQ 3).

Rugby and netball participants expressed different views, respectively, about how important it is to have the ideal body to participate in each sport (RQ 2). Consistent with Liechty et al.'s (2015) study, this study found that rugby offers more opportunities for people with all different body types and other characteristics, such as race and beauty, which are not essential for participating in rugby. Rugby players concurred that the sport requires a diversity of body types to fill each position, because it is so different. Although it is not always the case, they claim that positions at the front require a larger body size to maintain attack opposition, whilst positions at the back are typically smaller and more agile (RQ 2). Rugby players mentioned how their bodies had altered through playing rugby, with some body parts getting bigger and not fitting the "*ideal body*" that society has built for women (RQ2 & 3). However, as time went on, they began to believe that their additional attribute could help them improve their performance, which is consistent with previous studies (e.g., Liechty et al., 2015; Sabiston et al., 2019). Netballers' experiences with their bodies emerged as different. As a result of feeling pressure to conform to society's ideal body and the ideal body of a netballer, netballers' self-

confidence deteriorated (RQ 2 & 3). Netball is more liable than rugby to stigmatise players whose appearance does not measure up to its ideals (RQ 2). The stigma is frequently created by society and the media, because netball is primarily viewed as a feminine sport (Devonport et al., 2019) (RQ 3). For some netballers, the stigma caused them to have a poor relationship with their bodies, since they felt that their bodies did not match what society expected of them (RQ2 & 3).

Negative perceptions of body image were related to body commentary in sports. Body commentary, again, is associated with elevated anxiety, eating disorders, and body dissatisfaction (RQ 1 & 3). This study's findings about low self-esteem, low satisfaction, and a compulsive need to lose weight may all be related to body criticism. Again, numerous publications (e.g., Kerr, Berman, and Souza, 2006; Muscat and Long, 2008) have demonstrated that those instances are the outcome of body commentary that can come from a variety of individuals, including coaches, parents, players, friends, and other spectators (e.g., LeCouteur and Yong, 2022) (RQ 3).

Observed against the objectification theory, this study found that most participants had a positive sense of personal ownership of their bodies, which they valued for reasons other than how they looked to others (RQ 1). Instead of attempting to conform to society's ideal image, most people see their bodies as tools (D'abundo, 2007) (RQ 1 & 3). Through this, the participants recognised that adjusting their lifestyle (e.g., clothing, eating habits) had reduced negative self-objectification and improved their body image.

When asked about ideas for addressing and reducing body image issues, all participants answered passionately. Some suggested a narrative change in media behaviours (RQ 3), some wanted younger women or generations to be more visible (to diversify role models and help open possibilities for the majority), and some wanted broader conversation and education on how to promote inclusion and lessen body commentary on someone's appearance (RQ3).

Limitations and future research

The results of this study may not be generalisable to all university women who play rugby and netball, because participants came exclusively from the teams of one university in the north-east of England. Due to scheduling constraints, there were only eight participants. As such, the study is presented as preliminary work in the area. For future research, it would be beneficial if more people could participate, offering greater reliability and transferability of findings to other populations. Additionally, all participants are white British. In future research, participants from other races and geographical areas could be part of the sample, to allow for exploration of the significance for body image of racial and cultural background.

Future research could include male players, whose responses would be compared with those of female counterparts. Even though netball is a sport where women predominate, men are welcome to participate (White, 2003; in Hartmann, Tews and Pfister, 2003, pp. 35-52). Therefore, a future study could identify discrepancies or continuities between the sexes. The inclusion of other sports is another way to broaden the findings and gain a deeper understanding of the challenges women currently face in society. Swimming, for instance, is an individual sport which, according to Howells and Grogan (2012), has been classified as a slim build activity demanding low body mass index (BMI) for maximum performance (Byrne and McLean, 2002); a speed-focused sport favouring lighter than ideal weight (Robinson and Ferraro, 2004); and an aesthetic sport promoting thinness and beauty culture (Slater and Tiggemann, 2011). Future studies could continue to examine how sports could contribute to an increase in body satisfaction in sport cultures and in broader society, and help to design strategies for greater inclusivity.

AUTHOR CONTRIBUTIONS

Conceptualisation of project: Maria Lucia, Paul Davis. Introduction: Maria Lucia, Paul Davis, Ian Whyte. Method: Maria Lucia, Paul Davis, Ian Whyte. Data analysis: Maria Lucia, Paul Davis, Ian Whyte. Graphics: Ian Whyte. Discussion: Ian Whyte. Limitations and future research: Maria Lucia and Ian Whyte. Editing: Maria Lucia, Paul Davis, Ian Whyte.

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No potential conflict of interest was reported by the authors.

ETHICS STATEMENT

The study was performed in accordance with the Helsinki Declaration principles and ethical approval was granted by the local Ethics Committee of University of Sunderland, UK (011937 dated 26/05/2022).

INFORMED CONSENT STATEMENT

Informed consent was obtained from all subjects involved in the study.

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SCIENTIFIC JOURNAL OF SPORT AND PERFORMANCE

REVIEW ARTICLE

The Norwegian double-threshold method in distance running: Systematic literature review

Bence Kelemen . *School of Doctoral Studies. Hungarian University of Sport Science. Budapest, Hungary.*
Otto Benczenleitner. *Department of Athletics. Hungarian University of Sport Science. Budapest, Hungary.*
Laszlo Toth. *Department of Psychology and Sport Psychology. Hungarian University of Sport Science. Budapest, Hungary. Teacher Training Institute. Hungarian University of Sport Science. Budapest, Hungary.*

ABSTRACT

This study aimed to give a systematic literature review about the training of elite Norwegian long-distance runners (1500-10.000 meters). After a search in databases, we found 7 articles, that have systematically registered the training volume and intensity distribution of 13 elite runners over longer periods (n = 13). The results were the following: the best long-distance runners run 120 to 180 kilometers per week on average. The waist majority of this training (75-80 %) is done at low intensity (62-82% HRmax). Two to four sessions are done at the anaerobic threshold pace (82-20% HRmax), either in continuous or interval format during the base period, often done twice on the same day. One to two times weekly higher intensity sessions (>97% HRmax) are done, in form of short intervals (>800m) or short sprints. Longer intervals, above the anaerobic threshold (92-97 % HRmax) are rarely used during the base period. The training is closely monitored by a lactate meter or heart rate monitor. Before the racing season, in the pre-competition period, the athletes do fewer workouts at an anaerobic threshold pace and increase the number of sessions at a specific race pace.

Keywords: Performance analysis, Periodization, Anaerobic threshold, Long-distance running, Elite level.

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Corresponding author. *School of Doctoral Studies. Hungarian University of Sport Science. Budapest, Hungary.*
E-mail: bencekelemen95@gmail.com
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INTRODUCTION

Despite its relatively small population, Norway has produced several world-class long-distance runners. The Ingebrigtsen family has attracted attention in recent years, with three brothers winning the European outdoor 1500 m championships. They also have several continental records and an Olympic gold medal to their name. In the 1980s, women's athletes Grete Waitz and Ingrid Kristiansen achieved world records and international medals in both track races and marathon running. In the early 2000s, Marius Bakken set a new national record of 13:06.39 in the 5000 m and qualified twice for the World Championships finals, while Sondre Moen set a continental record in the marathon in 2017. Most recently Narve Nordas medalled at the world championships in the 1500 metres. What could be the secret of this small Northern European country? In the literature, the training of these runners, as well as several of Norway's elite distance runners, is well documented and published, and shows a relatively well-differentiated coherent pattern. To such an extent that in recent years Swedish runners have taken over the training system of Norwegian runners and are breaking national records (Kalle Berlgrund 3:33.70 in 1500 m in the final of the Doha World Championships and Andreas Almgren 7:34.31 in 3000 m, and 13:01.7 in 5000 m).

Races between 1500 m and 1000 m are dominated by aerobic energy production (Gastin, 2001), with 75-80% of the shorter 1500 m distance coming from aerobic energy, and 95% of the 10 km distance. These races are distinct in energy distribution and pacing from the shortest, 800 m middle distance. The latter is characterized by a steadily decelerating pace following a fast start (Kelemen et al., 2020; Filipas et al., 2018), while the longer distances all have a more even pace, with a steady middle section between a fast start and finish, where runners achieve the fastest splits (Tucker et al., 2006). A meta-study analysing the world's elite runners found that the training for the 800 m differed from that of the 1500 m race, with the latter distance specialists training in a similar way to the longer 5 and 10 km races (Haugen et al., 2021). Several factors have been identified that are related to and determine endurance performance. These are maximum oxygen uptake (VO_{2max}), running economy (RE), and speed associated with maximum oxygen uptake (Noakes et al., 1990; Noakes, 2001; Conley and Krahenbuhl; 1980). In addition to these factors, the anaerobic threshold and associated running speed (vAt) are the most predictive of distance running performance (Tjelta et al., 2012). A consensus has emerged among coaches and researchers that interaction between three main factors plays a role in the development of these parameters: training volume (number of kilometres over a time period), training density, and training intensity (Midgeley et al., 2007; Brandon, 1995). However, this combination may vary from one event to another and from one athlete to another (Seiler & Tonnessen, 2009). There may also be differences in the training tools that coaches use to achieve a given physiological adaptation.

This literature review aims to examine and analyse the literature documenting the training of Norwegian middle and long-distance elite runners over the last two decades. In particular, we searched for research that analyses the training of a particular athlete over a longer period. Our literature review seeks to answer the question of the volume, intensity, and training methods that characterize the training of Norwegian elite athletes.

Material and method

The literature search was conducted on 25 September 2023. After searching the Scopus, PubMed, Web of Science, ResearchGate, and Google Scholar online databases, 7 studies systematically recorded and processed the training volume and intensity of the best distance runners over an extended period. The following search terms were used using logical variables (AND, OR): 'Norwegian', 'distance running', 'elite level', training volume', training intensity, and 'training distribution'. A total of 13 runners' training was

documented (n = 13). In addition to these studies, a conference presentation by a coach was also used, as well as a longer account of one of the runners analysed (www.mariusbakken.com).

RESULTS

Training volume

On average, the runners ran between 120 and 180 kilometres, and they completed between 10 and 14 training sessions per week.

Grete Waitz averaged 123 kilometres in 10-11 training sessions weekly during the 1979 season when she set a national record of 8:31.75 for 3000 meters and a personal best of 4:00.58 for 1500 meters (Tjelta at al., 2014).

Ingrid Kristiansen recorded a weekly average of 155 kilometres over 49 weeks between November 1985 and October 1986, during which season she achieved a world record of 14:37.33 in the 5000 meters and a world record of 30:13.76 in the 10,000 meters (Enoksen et al., 2011; Tjelta & Enoksen, 2001).

In the 2012 season, Henrik Ingebrigtsen won the European outdoor championship in the 1500m and finished 5th in the same distance in the London Olympics. During the preparation season, he covered an average of 150 kilometres per week between November and May (Tjelta, 2013).

Henrik, Filip, and Jakon Ingebritsen averaged between 150 and 160 kilometres during 13-14 weeks of training between November 2018 and March 2019 [(Tjelta & Enoksen, 2010).

Members of the Norwegian team that finished 2nd in the junior category (17-19 years) at the 2008 European Championships in Cross Country Running averaged between 115 and 145 kilometres per week during different stages of training (Tjelta & Enoksen, 2010). This was higher compared to Spanish runners of junior age (23±2 years) who averaged 70 kilometres per week. The difference in volume was due to the low-intensity distances covered. Despite their younger age, the Norwegian runners ran closer to the world records at 1500 and 5000 meters, and the researchers found that the runners who were most successful over time were those who had done more training volume. Three seasons later, the two runners with the highest weekly volume won the 5000m and 10,000m at the European junior championships. The third runner placed 18th at the 2012 European Cross-County Championships, and the fourth runner, Henrik Ingebrigtsen, came first in the same event. The researcher concluded that a relatively high amount of aerobic training at this age may be a determinant of long-term success (Tjelta, 2016).

In a review study, three internationally successful Norwegian runners (Marius Bakken with 5000 m in 13:06.37, Bjornar Kristensen with 3000 m steeplechase in 8:16.75, Susanne Wigine with 10,000 m in 30:32.36) ran an average of 161 km during 13 training sessions per week during their training. This was reduced to 148 km per week during the competition period (Enoksen et al., 2011).

In Kalle Berglund's 2019 season (1500 m 3:33.70, 9th place at the World Championships in Doha), he ran an average of 135 km per week, while the maximum weekly volume was 158 km (Bengtsson, 2022).

Distribution of training intensity

The literature uses different intensity zone-based schemes to classify the training performed by endurance athletes (Seiler & Tonessen, 2009). In most cases, aerobic work is classified into three categories: Zone 1:

low intensity, with blood lactate below 2 mmol/L; Zone 2: intensity between the aerobic and anaerobic threshold, with blood lactate between 2 and 4 mmol/L. Zone 3 is where the intensity is above the anaerobic threshold when the blood lactate levels are above 4 mmol/L (Seiler & Kjerland, 2006). These three aerobic categories, complemented by two anaerobic zones, were used to create a 5-zone scale in the articles we analysed (Enoksen et al., 2011; Tjelta & Enoksen, 2010; Tjelta; 2016), which is presented in Table 2. Zone 4: anaerobic endurance training (at 3000 and 800 m race speeds where blood lactate levels are above 8 mmol/L) and Zone 5 includes alactic sprint training. The intensity of the training sessions was monitored using lactate measurement (Lactate Pro LT) and heart rate (HR).

Table 1. List of literature sources reviewed and results of athletes analysed (n = 13).

Study	Athlete	Period analysed	Performance (time)
A Longitudinal Case Study of the Training of the 2012 European 1500 m Track Champion (*Tjelta*, 2013)	Henrik Ingebrigtsen	2011-2012	1500 m- 3:35.43
Three Norwegian brothers all European 1500m champions: What is the secret? (*Tjelta*, 2019)	Henrik Ingebrigtsen Filip Ingebrigtsen Jakob Ingebrigtsen	2018-2019	3000 m- 7:36.85 1500 m- 3:30.82 1500 m- 3:30.16
Training and Philosophy that lead to Swedish record (*Bengtsson*, 2019)	Kalle Berglund	2018-2019	1500 m- 3:33.70
Distribution of Training Volume and Intensity of Elite Male and Female Track and Marathon Runners (*Enoksen et al*, 2011)	Marius Bakken Bjornar Kristensen Susanne Wigene	2004 2006 2009	5000 m- 13:06.39 3000 m st.- 8:16,37 10.000 m 30:32.26
A Case Study of the Training of Nine Times New York Marathon Winner Grete Waitz (*Tjelta et al*, 2014)	Grete Waitz	1979	1500 m-4:00.58 3000 m-8:31.75
The training of international level distance runners (*Tjelta*, 2016) Training volume and intensity (*Tjelta and Enoksen*, 2011)	Ingrid Kristiansen	1985- 1986	5000 m- 14:37.33 10.000 m-30:13.76
Training Characteristics of Male Junior Cross Country and Track Runners on European Top Level *(Tjelta and Enoksen*, 2010)	Sonde Moen Sindre Buraas Lars Erik Maide Henrik Ingebrigtsen	2008	15. European Cross-country Championship junior team race 2. place

Table 2. Five-zone intensity scale (source: Tjelta, 2016).

Intensity Zone	Type of training	Lactate (mmol/L)	% HRmax	Physiological adaptation
1	Easy and moderate continuous running	0.7-2.0	62-82	Recovery and improved running economy
2	Threshold training	2.0-4.0	82-92	Increase v AT and VO_{2max}
3	Intense aerobic intervals	4.0-8.0	92-97	Increase VO_{2max}
4	Anaerobic training, mainly at 800 m and 1500 m pace	>8.0	>97	Increase anaerobic capacity
5	Sprint			Increase speed

For the Ingebrigtsen brothers, the amount of training around and above the anaerobic threshold in the preparation period was 23-25% of the weekly mileage during the 2018-19 season, with limited work in the anaerobic zones. Zone 2 training was done 4 times a week. They completed two anaerobic threshold interval sessions on the same training day ("*double-threshold day*") twice a week. In the morning, 2-3 km intervals

were run with short rest (5x6 min), and in the afternoon, intervals between 400 m and 1000 m were run at 5 and 10 km race pace (12x1000 m with one-minute rest, or 25x 400 m with 0.5-minute rest). The volume of anaerobic threshold training sessions (Zone 2) was 8-12 km. This was supplemented with one Zone 4 workout per week (e.g. 20x200 m hill run), plus short sprints at 60 and 100-m distances. Between 75 and 80 percent of the total training, volume was done at low intensity in Zone 1 (Tjelta, 2019). These intensity distributions are typical of Henrik Ingebrigtsen's training in 2012 (see Figure 1) (Tjelta, 2013) and Kalle Berglund's training in 2019 (Bengtsson, 2019).

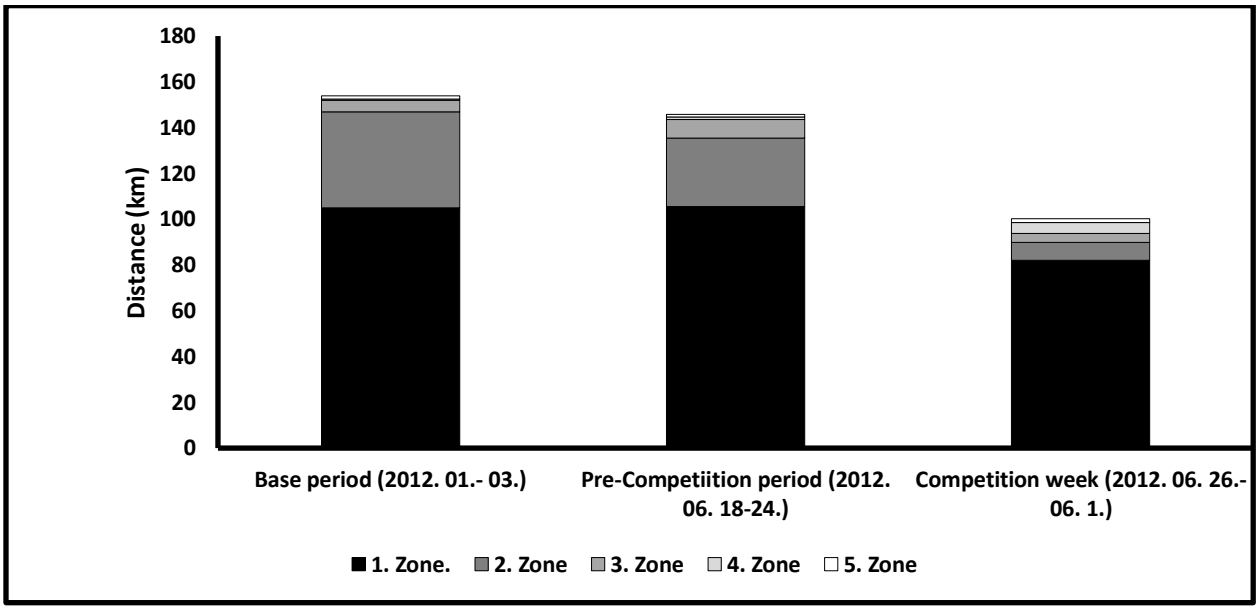

Figure 1. Henrik Ingebrigtsen's weekly kilometres and intensity distribution at different stages of his preparation in 2012 (Source: Tjelta, 2013).

During the pre-competition preparation period, the number of Zone 3 training sessions was reduced and the number of Zone 4 (3000- 800 m race pace) race-specific training sessions was increased. During the race period, in the race-free weeks, the ratio of low-intensity to high-intensity (Zone 2-5) mileage was 75:25, while in the race weeks the ratio was 80:20 (Tjelta, 2013).

A similar distribution was observed for Wigene, Bakken, and Kristensen (Enoksen et al., 2011). In the base period, the proportion of Zone 1 distances was 76% (average 123± 11 km per week), which increased to 79-80% during the preparation and competition periods. The number of kilometres completed in Zone 2 (anaerobic threshold) was 31.6 for the three runners (19.6%) weekly during the base period, decreasing to 14.5% and 13% in subsequent periods. The proportion of anaerobic endurance training (3000m and 800 m race pace) was 2.7; 3.6 and 4.9% respectively. Short sprints and strides accounted for 1.3-1.8% of the total training load.

Grete Waitz completed 52% of her training at a low intensity between November 1978 and October 1979, 43% of her training with sustained running in Zone 2. 2.5% of her training was in Zone 3, but this was mainly made up of 3000 m and 10,000 m races. He ran 2% in Zone 4 and 0.5% in Zone 5 (Tjelta et al., 2014).

Ingrid Kristiansen completed 91.31% of her average weekly 155 kilometres between November 1985 and October 1986 at low intensity (Zone 1), with 4.7% of her anaerobic threshold intensity (3:10 and 3:40 min/km

for her) during this period, in the form of sustained running at distances between 3 and 23 kilometres. The number of anaerobic endurance training sessions during the period was 10, which is only 0.37%, these were done at distances of 200 and 300 meters at 1500 meter race pace. Sprint training sessions accounted for 0.12% of the annual total, at 60 to 100-meter distances. The number of aerobic capacity workouts was 45/ 3.5% (Zone 3). This included races between 3 and 10 kilometres and intervals between 400 and 1000 meters with the same speeds (Tjelta, 2019).

During the training of the junior team, silver medallists at the 2008 European Championships in Cross Country Running, 78.3% of the distances covered were low intensity, 19.5% were at anaerobic threshold intensity (82-92% HRmax), typically in the form of intervals two to four times a week, with longer, sustained runs being less frequent. An anaerobic threshold training session was between 8 and 14 km (26-47 min) in volume. Aerobic capacity (92-97% HRmax) accounted for only 1.3% of the weekly volume, with athletes spending 0.5% of the workout at the highest speeds (Zone 5). During the competition period, the proportion of training sessions belonging to Zone 2 decreased to 11.7%, while that of training sessions developing aerobic capacity increased to 4.8% (Tjelta & Enoksen, 2010).

DISCUSSION

The most competitive Norwegian distance runners have high weekly mileage, averaging 160 km per week per year, which can be as high as 180 km in the winter preseason and 120 km in the summer racing season. Both the literature (Kariosk, 1984) and empirical observations by coaches are consistent with the finding that the training of the best elite distance runners is characterized by a similar volume of work. Of this volume, 75-80% of all but 1 of 13 runners (Grete Waitz) is low intensity (>2 mmol/L lactate) sustained running primarily for recovery and general aerobic endurance development. Stephen Seiler has published several studies concluding that most endurance athletes train at a ratio of 80:20 for low-intensity to above-anaerobic threshold training (Seiler, 2010). All athletes except Ingrid Kristiansen spend 15-20% of their weekly training on anaerobic threshold training, 30-40 km of work per week in Zone 2. What makes the Norwegian system special is the structure of these workouts. To be able to do this amount of work at this intensity has been solved since the 2000's mostly with "*double-threshold days*", where anaerobic threshold training is done in the morning and afternoon, mainly in the form of intervals (Casado et al., 2023). These workouts are closely monitored during rest periods using lactate measurement and heart rate monitoring. These are the tools and the appropriate coordination of intensity that allow this high volume of relatively fast, aerobic endurance training to be performed effectively and prevent over-exertion. Morning exercise on these days is in the form of longer interval distances (2-3 kilometres or 6-10 minutes) and lactate levels are kept below 2.5 mmol/L, an intensity equivalent to a marathon race pace. In many cases, a treadmill is used to optimize conditions in bad weather and reduce mechanical stress. The second training session of the day takes place 5-6 hours later, where shorter intervals with short rest periods are completed (10-12 x 1000 meters with 1-minute rest; 25 x 400 meters with 30 seconds rest, or 45-second intense stretches with 15 seconds rest). The short intense stretches allow them to work at higher intensities without lactate build-up, so they run at a 5-10 kilometre race pace while keeping lactate levels below 3.5 mmol/L for most of the training. On such a day, they complete 2 x 10-12 km in Zone 2 (Table 3). In the case of Marius Bakken, this was 2 minutes 53 seconds per kilometre before his personal best of 5000 meters in 2006, at 3 mmol/L over the 1000-meter repetition distance. Lactate threshold training is performed 2-4 times per week (Bakken, 2021). Another difference from the traditional approach is that no intense, longer (<800m) aerobic capacity interval training is performed in Zone 3 (92-97% HRmax) during the base period. This is consistent with recent research that the best distance runners preparation in other nations is characterized by tempo runs (Zone 2) and short intense intervals (Zone 4) (Casado et al., 2021). Except for short 60-100 m speed development sprints above the anaerobic threshold,

the best Norwegian distance runners train once a week at anaerobic intensities. During this training, anaerobic endurance and race speed economy are developed is done in the form of short intervals, which in several cases are hill runs (20 x 200 m hill runs, 70 seconds jogging back recovery). By combining these elements during the long training period, runners develop aerobic endurance to a very high level which is reflected in high VO_{2max} values (Tjelta & Enoksen, 2010). Henrik Ingrebrigtsen's 2010 VO_{2max} was 84.4 ml/kg/min (Tjelta, 2013), while Marius Bakken's was 87.4.

This high aerobic endurance in the weeks leading up to races enables them to perform intense race-specific high lactate training (>8 mmol/L). Anaerobic threshold training is also performed during the summer but at a lower frequency. The weekly training schedule during this period is more varied than during the preparation period and varies from week to week depending on the competitions. During the summer period, in the weeks without competition, the volume of work is done at the usual level (140- 160km/week).

Table 3. Kalle Berglund's one-week training during the 2018-2019 season's preseason (source: Bengtsson, 2019).

Day	Base period
Monday	AM 10 km easy PM 10 km easy, speed development
Tuesday	AM Anaerobic threshold workout: 5 x 6 minutes (1 min rest), 2.5 mmol/L PM Anaerobic threshold workout: 10 x1000 m (1 min rest), 3.5 mmol/L
Wednesday	10 km easy, strength and core
Thursday	AM Anaerobic threshold workout: 5 x 2 km (1 min rest), 2.5 mmol/L PM Anaerobic threshold workout: 25 x 400 m (30-sec rest), 3.5 mmol/L
Friday	10 km easy
Saturday	AM Hill training: 20 x 219-meter hills (70-sec jog back), 8,0 mmol/L PM 10 km easy
Sunday	AM 20 km long run PM Strength and core

CONCLUSION

The training of the most competitive Norwegian distance runners is characterized by high weekly volumes (120-180 km/week), most of which (70-80%) is done at low intensity (62-82% HRmax; 07-2.0 mmol lactate). High-intensity training is mostly done around the anaerobic threshold (82-92% HRmax; 2-4 mmol/L lactate). These workouts are typically performed in interval form 2-4 times per week, often twice on a training day ("*double threshold day*"). To achieve the right intensity and prevent overload, lactate measurement and heart rate monitoring are used during the workouts. The remainder of high-intensity workouts (>97% HRmax; >8.0 mmol/L lactate) are faster, short intervals (>800 m), and short sprints 1-2 times per week. The use of intense, longer-duration aerobic capacity intervals (92-97% HRmax; 4.0-8.0 mmol/L lactate) is not typical during the base period. Race-specific longer interval training at race speeds and the development of anaerobic capacity are started 6-10 weeks before the race, with a parallel reduction in the number of training sessions close to the anaerobic threshold.

AUTHOR CONTRIBUTIONS

Bence Kelemen developed the theoretical formalism, conducted a systematic review of the research and summarised the data. Authors Bence Kelemen and Ottó Benczenleitner contributed to the final version of the manuscript. The project was supervised by László Tóth.

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ORIGINAL ARTICLE

The simple low-cost guide to athlete fatigue monitoring

Farzad Jalilvand . *Department of Kinesiology. California State University. Northridge, United States of America. Cardiff School of Sport and Health Sciences. Cardiff Metropolitan University. Cardiff, United Kingdom.*
Dale W. Chapman. *Curtin School of Allied Health. Curtin University. Perth, Australia.*
Jeremy M. Sheppard. *Canadian Sport Institute Pacific. Whistler, Canada.*
Shane D. Stecyk. *Department of Kinesiology. California State University. Northridge, United States of America.*
Norbert Banoocy. *Performance Department. Sønderjyske Fodbold. Haderslev, Denmark.*
Paulo H. Marchetti. *Department of Kinesiology. California State University. Northridge, United States of America.*
Matthew J. Voss. *High Performance Department. U.S Ski and Snowboard. Utah, United States of America.*
Alireza Rabbani. *Sports Science Department. Al-Ittihad Kalba FC. Kalba, United Arab Emirates.*
Daniel Martinez. *Athletics Department. Trinity University. Texas, United States of America.*
Jonathan D. Hughes. *Cardiff School of Sport and Health Sciences. Cardiff Metropolitan University. Cardiff, United Kingdom.*

ABSTRACT

As the demands of training and competition increase so does the potential risk of injury and illness to the athlete whilst seeking to maximize their adaptive processes to promote optimal performance. Therefore, as a strategy to mitigate this risk, strength and conditioning coaches need reliable and valid monitoring tools to track an athlete's status throughout training to ensure progression of adaptation, and that the athlete remains healthy throughout the adaptation process. The purpose of this article is to provide the reader an evidence-driven outline of basic, simple, and cost-effective monitoring tools which are reliable and valid to observe the fitness/fatigue paradigm and track overall athlete physical adaptation and health throughout the training process, suitable for most settings. A weekly example calculating sessional ratings of perceived exertion (sRPE), training load, monotony, and strain is provided along with a basic monitoring system as a guide for the reader.
Keywords: Sport medicine, Injury prevention, Load management, Overtraining.

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Corresponding author. *Cardiff Metropolitan University, Cardiff School of Sport and Health Sciences. Cyncoed Road, Cardiff, CF23 6XD. United Kingdom.*
E-mail: coachfaz@ethossportscience.com
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INTRODUCTION

To realize athletic performance, the strength and conditioning coach (S&C) has two main goals in training any athlete. First, to improve their athletic capabilities to achieve maximum potential and secondly, develop and use specific training protocols that facilitate appropriate timing of peak performance while reducing the risk of injuries (Dorgo, 2009). By achieving these two goals, the S&C coach supports the technical coach and other medical staff by presenting an athlete with a greater likelihood of being physically healthy and capable to give the desired performance. Thus, the S&C coach should use various assessment tools to monitor and track the effects of a training program, the athlete' readiness to compete, and their overall well-being (McGuigan et al., 2020).

Throughout the training process, the S&C coach will structure different configurations of training loads (TL) (i.e. various training intensities and volume of work) depending on the timeframe and positioning within a season (Plisk & Stone, 2003). Each training type presents a novel stimulus that will promote a specific, associated, adaptation within the context of the specific sporting and athlete needs. This may include one or more of; changes to overall body composition, increasing specific muscle cross sectional area, improving maximal strength, enhancing rate of force development, and/or power production. For example, during the preseason, higher TL may be prescribed to drive specific physiological adaptations such as maximal strength and power or aerobic conditioning (Plisk & Stone, 2003). However, these increases are typically accompanied by higher residual fatigue and thus an increased risk of injury, illness, and underperformance (Drew & Finch, 2016; Stone et al., 2007). If this trend of higher TL is maintained without adequate recovery, then the athlete will eventually reach a state of non-functional overreaching and/or overtraining, which is detrimental to the athletes performance and ultimately their health (Kellmann et al., 2018).

Importantly, the S&C coach is concerned with the athletes' ability to tolerate the prescribed TL and the associated adaptations in either a negative or positive direction (Cunanan et al., 2018). Therefore, quantifying the specific training load of each type of training prescribed is imperative for the S&C coach to utilize in their planning and monitoring, so that subsequent decisions are well informed. Simply put, if we analogize training as medicine, we must start with knowing the dose by type. However, there are varying types of training prescribed and various stimulus-response relationships at play, making it difficult to scale and normalize between training types. How does a coach compare strengths sessions with field sessions, mobility sessions with conditioning sessions? Knowing these loads by type is critical but gaining an understanding of load across all training types and in total allows the coach to make better dose-response decisions.

Within the context of sports, adaptation to training is reflective of the organisms' (in this scenario the athlete as the system) ability to adjust and adapt to the stimuli that disrupts homeostasis throughout the training process and the systems' ability to return to homeostasis (recover for the next stimuli) (Chiu & Barnes, 2003; Cunanan et al., 2018; Plisk & Stone, 2003; Selye, 1956). A negative trend in adaptations may indicate, and result, in an overall residual fatigue state that without sufficient recovery, over a prolonged period, may contribute to injuries, illness, and reduced performance leading to overreaching and in severe cases overtraining (Edwards, 2018; Thorpe et al., 2017). Positive adaptive responses, indicates a greater level of fitness and preparedness for competition (Zatsiorsky et al., 2021). Therefore, the purpose of this review is two-fold, (i) provide the reader with the empirical evidence that supports simple tools utilized by the S&C coach in a real-world setting to monitor fatigue, the adaptative response and overall health of the athlete, and (ii) provide a practical system for how these tools can be implemented throughout the training process.

A brief note on quantification of load

A plethora of research exists in the realm of load quantification and load response (Borresen & Lambert, 2009; Foster, 1998; Fox et al., 2017; Fullagar et al., 2015; Halson, 2014; Thorpe et al., 2017). The reader is therefore directed to the referenced articles to further understand the relationship between load and load response. However, a few salient points need to be addressed. Load can be defined as either external or internal. Internal load refers to the physiological responses to a stimulus and can be perceived (subjective) or measurable (objective), whereas external load refers to the physical work performed (Haddad et al., 2017; Impellizzeri et al., 2004; Impellizzeri et al., 2005). What needs to be considered when examining internal or external load is the variation of responses associated with the stimulus, whether internal or external. For example, a key step in managing the internal load response, requires an understanding of the amount of external load placed on the athlete. For example, Barrett (2017) demonstrated that real time data such as high speed running (HSR) total distance, and maximum velocity can be used in real time to modulate training, thus indirectly influencing internal load. The internal response to the external load applied derives the outcome of the training (Saw et al., 2017). The individual response (i.e., internal load) to the same external load is highly individual and has varying response rates as it is impacted by various factors such as previous training status, genetics, individual characteristics, health, environment, nutrition, and psychological status (Vanrenterghem et al., 2017). The adaptation pathway for various external and internal load with a combination of various methods as highlighted in this article will prove useful. This notion is strengthened by Inoue et al. (2022) in their meta-analyses that there is an agreement between the coaches and athlete as it relates to moderate to hard load prescription, but not easy efforts. It is therefore important to add a looped feedback system between the athletes and the S&C to provide further context as to the readiness of the athletes on the day of physical activity. This is also in line with Bartlett et al. (2017) were 36 out of 41 Australian rules footballers demonstrated that session distance and not HSR was the greatest predictor of RPE. Whereas only 2 players demonstrated that $m \cdot min^{-1}$ was predictive of RPE, and 3 players showed that HSR and % HSR was a better predictor of RPE compared to the other metrics. These described outcomes from Bartlett et al. (2017), strengthens the need for an individualized approach utilizing multiple tools and metrics in conjunction and not in isolation to evaluate the athlete's readiness.

UNDERSTANDING AND APPLYING SUBJECTIVE DATA

Triangulating the most common denominator of athlete monitoring, fatigue management is a topic of interest for the S&C coach (McGuigan et al., 2020; Taylor et al., 2012). For the S&C coach to understand the physiological and psychological load an athlete is experiencing whether acutely or chronically, subjective questionnaires can be used to monitor what is referred to as the internal (athlete perceived) load of any given training session (Foster et al., 2001; Kellmann et al., 2018). Depending on the response, this information can then be used to inform, adjust, and prescribe appropriate future training loads. Furthermore, consistent reporting of high subjective scores after competition by athletes can be used to guide coaching and support staff to a potential increased risk of injury or illness (Hamlin et al., 2019; Rogalski et al., 2013).

Session rating of perceived exertion

Sessional rating of perceived exertion (sRPE) is a simple, short, subjective question-based assessment tool that the athlete answers after either a training session or competition. The response to the short questionnaire provides a S&C coach with an internal (perceived) intensity rating using a scale from 0-10 (Foster et al., 2001; Singh et al., 2007). Each number has a descriptor (0-1 = very easy, 2 = easy, 3 = moderate, 4 = somewhat hard, 5-6 = hard, 7-9 = very hard, and 10 = maximal) to assist the athlete to anchor their internal perception to a valid and reliable response (Foster et al., 2001). The athletes' response can be used to calculate an internal TL reflective of what the athlete experiences during a training session or game. The TL

is calculated by multiplying the sRPE score by the duration of the training session or game (Calculation 1) and is expressed as arbitrary units (A.U) (Foster et al., 1996; Foster et al., 2001).

TL = duration in minutes x sRPE (*Calculation 1*)
Example: 60 x 6 = 360 A.U

The use of session rating of perceived exertion (sRPE) has been reported as reliable and valid for monitoring athletes of different competitive levels and across various sports or team settings and is widely used amongst S&C coaches (Haddad et al., 2017; Taylor et al., 2012). An athletes responses should not be taken immediately after the training session as they may elevate or lower the responses based on the final training modality at the end of the session (Singh et al., 2007). Singh et al. (2007) observed that the sRPE can be recorded 10 minutes after the training session is completed as there were no differences observed in the sRPE scores compared to waiting 30 minutes after completing different modes of resistance training. This change in recording protocol when implemented provides for a more practical implementation of sRPE in sporting environments. Further, sRPE is reliable when compared to objective measures in quantifying TL in resistance and aerobic training, HSR, plyometrics and speed, interval training, regardless of whether it is a male and female athlete population (Haddad et al., 2017). The reader is referred to the excellent review by Haddad et al. (2017) to further understand the relationship between sRPE and populations within different sports.

Validation of sRPE has been examined across sports in different contexts. Impellizzeri et al. (2004) observed moderate to strong correlations (r = 0.71) between sRPE TL and heart rate-based TL across 27 training sessions in young soccer players. Alexiou and Coutts (2008) reported similar results in elite female soccer players with moderate to strong correlations between sRPE TL and heart rate-based TL (r = 0.56-0.97) within individual players. To show its wider validity there has been evidence of strong relationships in male Canadian football players (r = 0.65-0.91) (Clarke et al., 2013), adolescent basketball players (r = 0.80-0.95) (Lupo et al., 2017), Karate (r = 0.65-0.95) Tabben et al. (2015), and resistance training (ICC = 0.88) (Day et al., 2004).

Use of this TL data is a pragmatic approach for S&C coaches to monitor the internal stress of the athlete with different types of training sessions i.e. sport specific practice, gym and field based sessions, or competitive events (Halson, 2014). Using TL data encourages the implementation of appropriate training strategies e.g. adding a recovery session or increasing/decreasing intensity of a particular session/drill (Saw et al., 2016b). Furthermore, the information can aid in tracking the overall training responses of athletes on a week-to-week basis to monitor the overall stress that athletes experience (Foster C et al., 1996; Halson, 2014).

Training monotony and strain

Monotony and strain can provide useful information regarding the broader variability of TL across a microcycle Foster et al. (2001), and these can be calculated using 'external load' quantification (e.g. total load lifted in resistance sessions, total distance run, etc.), but commonly these are used with arbitrary unit measures like sRPE (that are a product of both external load; minutes and internal load; rating of perceived exertion). Training monotony represents the day-to-day variability in training and is calculated by dividing the weekly mean TL by the standard deviation of the daily load calculated over a week (Calculation 2) (Foster, 1998).

Monotony = weekly mean TL / SD (*Calculation 2*)

The resulting metric can be useful to detect if large or small overall TL variations are occurring regardless of whether the types of training being performed are varied. For example, high monotony (little variation) exhibited via continuous high TL, may increase the likelihood of overtraining syndrome (Foster, 1998). This can be evident in equating similar TL's across macrocycles but different measures of strain and monotony may be present (Comyns & Flanagan, 2013). Thus, tracking the variations in TL (high, moderate, and low) and their association to monotony can be useful for the S&C coach to account for adjusting the TL and implementing recovery methods within microcycles (Haddad et al., 2017).

To expand on monotony, training strain, a derived calculation from monotony, can be another useful way to monitor high TL. This is calculated via the weekly TL multiplied by the monotony score (Calculation 3).

Strain = weekly TL * monotony (*Calculation 3*)

High strain can occur when the TL is high with small variations in load (Foster, 1998; Foster et al., 2001). High strain can be considered to represent a higher overall weekly training stress in the athlete and may increase the chance of illness and injury (Foster et al., 2001). Table 1 provides an example of with reference to sRPE, monotony, and strain for a microcycle.

Table 1. Calculations for sRPE, Monotony, and Strain example. Calculations are expressed as arbitrary units.

	Type	RPE	Duration	Unit Load	Daily Load
Mon	Str (UB) Conditioning/Skill	6 7.5	40 60	240 450	690
Tue	Str (LB) Skill/Tactical	6 5	40 45	240 225	465
Wed	Off			0	0
Thurs	Str (WB) Speed/Skill	5 6	40 40	200 240	440
Fri	Skill/Tact + Cond	6 8.5	40 30	240 255	495
Sat/Sun	Off			0	0
Week Total				2090	
Daily mean load				298.5	
Daily SD				283.8	
Monotony				1.05	
Strain				2194.5	

Note. Cond = Conditioning session; Str = Strength; Tact = Tactical training; UB= Upper body; LB= Lower body; WB= Whole Body.

Wellness questionnaires

Wellness questionnaires can be utilized to provide further context on how the athlete is responding to training and whether adequate recovery is being achieved (Taylor et al., 2012). Typically, these questionnaires gather subjective information regarding most commonly the athlete's sleep quality and length, feelings of overall fatigue, stress, and muscle soreness (Saw et al., 2016b; Taylor et al., 2012). This information provides greater context to the athletes' experience both physically and psychologically outside of their training environment (Saw et al., 2016a). Given, positive adaptations tend to be achieved when the athlete has recovered both physically and psychologically (Barnett, 2006; Halson, 2014), it is pragmatic to include an assessment of the athlete's overall well-being in conjunction with sRPE. However, it is beyond the scope of this article to address all facets of well-being. While overall, the recovery process depends on many factors such as sleep hygiene,

nutrition, and psychological stress (Fullagar et al., 2015; Halson, 2008), practitioners with limited resources should primarily focus on the importance of monitoring sleep, which can be considered the most simple and yet sophisticated tool for recovery and athletic performance (Halson, 2008). Secondary to monitoring sleep, tracking muscle soreness can be a useful tool to modulate the training program to help athletes better cope with the physiological stress they may experience (Drew & Finch, 2016). Combining the monitoring of sleep and soreness is a viable and an inexpensive option for the S&C to monitor the overall wellness of the athletes.

The use of wearable technology allows the athlete, technical coach, and S&C coach to understand the sleep, personal well-being patterns that may negatively impact on performance. Athletes performing at the elite and collegiate levels have been reported to lack the necessary sleep for optimal performance (Bolin, 2019; Lastella et al., 2015). Impaired or restricted sleep can lead to reduced mean power production in male footballers Abedelmalek et al. (2013) and male physical education students (Souissi et al., 2008). Furthermore, evidence suggests that lack of sleep also affects lower body strength (Reilly & Piercy, 1994) and cardiovascular performance (Azboy & Kaygisiz, 2009). Creating a questionnaire and education resource that outlines the athlete's sleep patterns is a good starting point (Rogers et al., 1993). However, practitioners are encouraged to utilize validated questionnaires where possible before creating one. Including the other factors previously discussed will also be beneficial to track at the same time to provide further context for decision making purposes (Taylor et al., 2012). The contextual information gathered therefore will aid the S&C, technical, and sports medicine staff to modulate training for the desired physiological adaptations. An example of a soreness and sleep questionnaire can be found in Figure 1.

	1	2	3	4	5	Score
How well did you sleep	I feel rested	Good	Difficulty falling asleep	Tossing and turning	Did not sleep	
Soreness	No soreness	Little soreness	Feeling good	Feeling sore	Extremely sore	

*Larger overall score in wellness may indicate inhibited athlete recoverability

Figure 1. Sample of a simple wellness questionnaire.

The wellness questionnaire (Figure 1) should be collected in the morning prior to training commencing to assess how athletes have coped with the previous day's training or game and identifying any potential problems. Collecting the information prior to the sessions commencing will provide time for practitioners to make necessary adjustments to the training plan, such as TL, intensity, and, volume in conjunction with technical coaches and medical staff (Thorpe et al., 2017). In addition, any interventions such as treatment or increased recovery modalities can be planned to help athletes cope with the session or complete an alternative plan. In some scenarios, the collection of the early morning responses may not be feasible, which would leave room for collecting the information either post-training or at the end of the day (Saw et al., 2015). In this scenario, only acute response to the session can be analysed, and the wellness questionnaire can no longer be used as an evaluation of training readiness and load adjustments. Regardless of the time window

used, consistency in approach is fundamental. Lack of consistency may result in potential loss of critical information regarding the athletes' health and critical decisions may be overlooked by the support staff regarding the athletes' overall health.

Objective data

Gathering objective data such as volume, intensity, kinetic and kinematic data can aid the S&C coach to evaluate the athlete's physical readiness for their next training stimuli during a microcycle and the magnitude of training adaptation that has occurred pre- and post-macrocycle. Typically, objective tests involve assessing both the underlying athletic abilities and performance orientated metrics. Tests such as the vertical jump, or countermovement jump (CMJ), lower and upper body strength, linear speed, and change-of-direction speed (Alricsson et al., 2001; Fry & Kraemer, 1991; Hopkins et al., 2001; Reynolds et al., 2006) are used. The application of these tests at multiple intervals during a microcycle and more broadly during a mesocycle can concurrently be utilized to assess athlete readiness and fatigue, or more specifically neuromuscular fatigue (Halson, 2014). Neuromuscular fatigue is defined as a prolonged exercise induced reduction in force or power, regardless of whether the specific task can be sustained or not (Bigland-Ritchie & Woods, 1984). Therefore, it would be pragmatic to assess this component regularly. This review will also cover the monitoring of resistance training with respect to intensity and volume of work done as a means of an inexpensive method to quantify the stimulus placed on the athletes (Scott et al., 2016; Stone et al., 2007; Zatsiorsky et al., 2021).

Neuromuscular fatigue assessment via the stretch shortening cycle (SCC)

The importance in monitoring neuromuscular fatigue may not be as clearly understood, despite it being well-defined term in the literature (Halson, 2014). Fatigue as a construct, in simplistic terms relates to a decrement in performance or force producing capabilities following training is comprised of three factors: 1) metabolic fatigue resulting from a lack of energy availability and is generally short term in impact (less than 90mins) and reversible provided energy availability is provided; 2) neuromuscular fatigue is of a longer duration (possibly up to 36hrs) and is an impairment in force producing capabilities due to restrictions imposed on the signalling pathways distal to the spinal cord through to the muscle fibre neuromuscular junction, is harder to noninvasively measure and predict or influence the time course of recovery; 3) Central Nervous System fatigue or colloquially Cognitive fatigue, which is a force production decrement that results due to a disturbance in central nervous pathway signally and can result from such instances as prolonged sleep deprivation, extensive learning tasks or application of mental faculties (Bigland-Ritchie & Woods, 1984; Halson, 2008, 2014; Kellmann et al., 2018). Considering these three broad facets of fatigue, S&C coaches will commonly prescribe training sessions that consider the need to refuel and thus recover metabolically. However, the difficulty and variation of how neuromuscular fatigue presents, along with the negative impact on an athlete's readiness to perform in their next training session, places a strong emphasis on seeking to quantify and monitor the neuromuscular systems effectively.

The use of the CMJ to assess the stretch shortening cycle (SCC) as a representation of the neuromuscular systems functionality of the lower body via associated kinematic and kinetic data is now common practice amongst practitioners (Claudino et al., 2017; Taylor et al., 2012). The most common metrics reported from CMJ performance are jump height, average or peak power, average or peak velocity, and average or peak force (Rago et al., 2018). Tracking these metrics has been deemed useful across a competitive season (French et al., 2004; McGuigan et al., 2009). The S&C can also be confident with assessing the CMJ jump and jump metrics due to little variation within subjects (<5%) as reported by Markovic et al. (2004). Furthermore, the CMJ can now easily be assessed via many small portable devices, including jump mats, linear position transducers [LPTs], accelerometers, and smartphone apps Rago et al. (2018) which may be

a more pragmatic and cost effective. LPT's can be a useful tool in measuring neuromuscular fatigue during training and competitive cycles across different sports when access to force plates is limited (i.e., financially, or logistical). To highlight this notion, Gathercole et al. (2015) investigated acute fatigue in snowboard cross athletes across 19 weeks of training via a LPT. The authors observed large increases in jump duration (longer time to take off) which was identified as eccentric duration (effect size (ES) 1.91) and total duration of the CMJ (ES 1.90) and moderate decrease in concentric measures such as relative absolute mean force (ES 1.23), relative peak force (ES 1.25) 24 hours post training session with the coefficient of variation ranging from 2-16.2% in the chosen displacement data. Moreover, CMJ technique was altered when the athletes were in a fatigued state, which can also allude to a shift in jumping strategy as a means to reduce the likelihood of injury (Kennedy & Drake, 2017). From a practical standpoint, this information could be of use to the S&C to make quick decisions i.e., before planned training sessions to facilitate changes in programming to accommodate the athlete's status. Contact mat systems are also a viable option to monitor fatigue as it relates to measuring the CMJ and squat jump (SJ) Kenny et al. (2012) in combination with smartphone applications (Rago et al., 2018). Rago et al. (2018) reported that moderate to good reliability exists for flight time and jump height (ICC = 0.54-0.97) between contact mat, portable force plates, smart phone application, and accelerometer (Rago et al., 2018). This is in line with Kenny et al. (2012) which also found good test-retest reliability for a jump mat system in comparison to force plates (ICC = 0.99) between the CMJ and the SJ, but not the drop jump (ICC = 0.64). However, Markwick et al. (2015b) reported good reliability for the reactive strength index across various drop heights 20cm (ICC = 0.821-0.982), 30cm (ICC = 0.574-0.951), 40cm (ICC = 0.797-0.979), and 50cm (ICC = 0.991-0.997) utilizing a jump mat system in male professional basketball players. Similar results have been reported via Tenelsen et al. (2019) with different drop heights 24cm (ICC = 0.83), 43cm (ICC = 0.89), and 62cm (ICC = 0.75). Although, good reliability has been shown in the aforementioned studies, it is important for the S&C to understand that different types of jump mat systems have been used across these studies and therefore practitioners must select these devices based on their validity and reliability when monitoring athletes.

A pragmatic approach in using jump mats to assess NMF is to track decrements in CMJ height throughout short term training/competitive cycles (Delextrat et al., 2012; Loturco et al., 2017; McGahan et al., 2019; Oliver et al., 2015). Though, jump height alone may be a crude estimate of NMF due to variations in jumping strategy during a fatigued state (Gathercole et al., 2015; Jalilvand et al., 2019; Kennedy & Drake, 2017), it is still a viable and cost-effective way to monitor athletes. Furthermore, it is also suggested that subjective measures should be used in combination with CMJ height due to potential minimal changes in this metric post competitive activity (Alba-Jiménez et al., 2022; Lombard et al., 2021).

Drop Jump (DJ)

Additional to the CMJ, the DJ may be useful to detect neuromuscular fatigue (Hamilton, 2009). The DJ is done by stepping off a box of predetermined height and upon landing immediately rebounding explosively for maximal height (Pedley et al., 2017). The derived calculation from the DJ is called the reactive strength index (RSI) and can serve as a method of measuring explosiveness (Barker et al., 2018) (Calculation 4a). The explosive nature of the jump mimics many athletic tasks and may be a more reliable way to assess fatigue in the SSC (Flanagan et al., 2008). The RSI can be recorded via the use of contact mats. To interpret the outcome metrics within a neuromuscular fatigue framework, a lower ratio from a baseline established via assessing change in relation to the typical error (TE) established as coefficient of variation (CV) of the test is associated with a reduction in explosive capabilities, and thus a reduction in performance (Twist & Highton, 2013). A true change in the score in either positive or negative direction, has to be greater than the CV of the test (Hopkins, 2004; Hopkins et al., 2001). The reliability of the RSI has been confirmed by Markwick et al. (2015a) who tested the DJ across 20-, 40-, and 50 cm in elite male basketball players with the CV ranging

from 2.1-3.1 % across all heights. The use of multiple drop heights is recommended due to the variation of athlete capabilities. This is highlighted by Byrne et al. (2017) during the exploration of optimal drop height and drop heights from 30-60cm, they observed CV ranging from 2.98% in optimal conditions and 4.2% across all heights. Although deemed reliable across day-to-day testing, Beattie et al. Beattie and Flanagan (2015) stressed in their study that RSI may not be sensitive to detect changes across the whole squad and recommended that each athlete should have an established threshold to detect individual changes in RSI. An additional way to assess RSI is to utilize a modified version where a CMJ take-off time is compared to contact time (Suchomel et al., 2015). This method may be more suitable for athletes that have not been familiarized with the DJ. The calculation is similar to the DJ replaced with the CMJ and the contact time with time to take-off to adjust the formula (Calculation 4b).

Though, previous research has established a 30cm box height is reliable in assessing RSI Flanagan et al. (2008), there is scope for the box height to be normalized to the start of a macro cycle's pretest result. Thus, regularly assessing the optimal DJ height allows for a better understanding of the athlete's current capability and adjusting the height of the box used for assessment can lead to a more realistic and current training status understanding. Hamilton (2009) reported that the RSI is a sensitive measure to track acute neuromuscular fatigue in elite young soccer players during a condensed tournament play, highlighting the importance of tracking for understanding training status. Furthermore, Fitzpatrick et al. (2019) extended this observation, reporting that RSI was sensitive to performance changes after 24 hours of strenuous exercise in youth soccer players. Interestingly, CMJ, squat jump and subjective wellness measures were included in this study and did not show any sensitivity to changes in fatigue. This highlights the need to include multiple assessments as each athlete my respond differently depending on the task and measurement.

RSI = Jump height / Contact time (*Calculation* 4a)
Example: 0.38m / 0.230s = 1.65

Modified RSI = Jump height / Take-off (*Calculation* 4b)
Example: 0.38m / 0.310= 1.22

Resistance training volume and intensity as a means of managing stimulus

This section will primarily underline resistance training as a training modality due to its commonality and use. However, other training modalities (i.e., maximal speed, aerobic speed) can be used and adapted to regulate the training session stimulus. It is important that data which characterizes the resistance training, both planned and completed (actual), such as volume load (VL) and training intensity (TI) is highly useful to track throughout an athletes career (Stone et al., 2007). This information provides adaptive situational context when combined with wellness, and sRPE data (Day et al., 2004; Singh et al., 2007) to better understand when, why, and how an athlete responded either positively or negatively to any given training stimuli. VL is defined as an estimate of workload for a session and accounts for the total weight lifted for an exercise session and is expressed as metric ton Haff (2010), this should be captured both as what is/was planned for a training session and what was actually completed during the training session by the athlete. TI is defined as the average weight lifted for an individual exercise or the entire a training session (Haff, 2010). Both components can be useful to track as it relates to fatigue within the realm of resistance training (Scott et al., 2016). VL has been shown to be a good measure of physiological stress and external load (Genner & Weston, 2014) and can be useful when comparing to sRPE scores. TI is also useful to track as it relates to the average weight lifted across a training session (Haff, 2010). Monitoring the TI can aid the strength and conditioning coach's understanding of the contribution of VL and TI based on the type of exercise and category of exercises within the given training season (Haff, 2010; Scott et al., 2016; Stone et al., 2007). As an extension

to this process which provides further contextual insight into an athlete's adaptation, and the strength and conditioning coach's planning process at no financial cost, the VL and TI can be further categorized based on the type of lifts performed such as, single or multi joint lifts, dynamic/explosive power lifts, closed or open chain etc. Over time the strength and conditioning coach may then see trends associated to better training readiness or greater levels of fatigue when different VL and TI are completed across the different lift categories.

A few caveats to consider when monitoring VL is that this is a direct measure of the absolute weight lifted and may not reflect the relative intensity or the relative load of a gym-based exercise (Brzycki, 1993). This is especially important when comparing between athletes in terms of the stimulus induced adaptation or the individual stimulus applied based on the same exercise. An example is provided with two athletes performing the same exercise with the same prescribed intensity (% RM) but with different loads (Table 2 and 3). The absolute tonnage lifted for each athlete, relative VL, and relative TI is described. Due to the difference in absolute tonnage lifted between athletes it would be difficult to compare the individuals. Therefore, an easy solution is to normalize the tonnage relative to the athlete using Calculation 5b, which provides a clearer understanding of the volume load stimulus applied. However, the relative intensity should be considered for each lift Carroll et al. (2019) as highlighted in Table 3. Though, each athlete is working at a 77% RM, the relative intensity differs for each. Athlete A and B are both instructed to squat 4 sets of 8 at 77% of 1RM, resulting in athlete A squatting at 115Kg and athlete B at 85kg. However, even though both athletes are performing the exercises below their 8RM, the relative intensity remains high. Since their 8RM loads (athlete A 120kg vs. athlete B 88kg) is established, athlete A and B are lifting 115kg and 85 of their 8RM. This results in a higher relative intensity than prescribed and may cause athletes to fail in subsequent sets and therefore the targeted stimuli may not be met. The opposite holds true as well. Considering our first example of athlete A. This athlete now must complete 8 sets of 4 repetitions at 77% of 1RM. Athlete A would have a 4RM load of 135kg, this results in a relative intensity of 85% (115/135). It is therefore important to consider the loading schemes and targeted stimuli when considering gym-based exercises to ensure that the athlete is targeting the desired stimuli.
Calculation 5a,5b, and 5c provides an example of how to calculate the VL, Relative VL, and Relative TI.

Table 2. Descriptive characteristics of sample athletes.

Athlete A back squat	Athlete B back squat
1RM = 150kg	1RM = 110kg
8RM = 120Kg	8RM = 88Kg

Table 3. Calculations.

Measurement	Athlete A	Athlete B
Absolute volume (VL in KG)	4x8x115 = 3680	4x8x85 = 2720
Relative Volume (A.U)	4x8x 77% RM = 2464	4x8x 77% RM = 2464
Relative intensity %	115kg/120Kg = 95.8%	85kg/88kg = 96.5 %

VL = sets x repetitions x weight lifted (kg/lb) (*Calculation* 5a)
TI = VL/Total repetitions

Relative VL = sets x repetitions x % RM (*Calculation* 5b)
TI = VL/Total repetitions

Relative intensity = % RM prescribed / Absolute RM (*Calculation* 5c)

IMPLEMENTATION

The S&C coach should aim to implement a consistent system of assessment within their sporting context, and available resources. The assessments described above are cost effective and time efficient for most settings. The following section highlights how to implement the sRPE, Wellness questionnaires, and CMJ to inform the training process and has been based on the authors practical experiences. We will not detail the statistical analysis as this is beyond the manuscript scope, however for details on how to analyse and interpret the described tests and associated trends see descriptions by Hopkins and Stone et al. (Hopkins, 2004; Stone et al., 2007). The reader should seek to implement a monitoring system that fits within their sporting context and constraints. The general recommendation for weekly monitoring (Table 4) described uses minimal equipment and efficiently expands on the planning processes that S&C coaches should already be applying.

Table 4. General monitoring system for a microcycle example adapted from McGuigan et al., 2020; Taylor et al., 2012.

Assessment	Frequency	Rationale and purpose
CMJ	Ideally every day pre and post sessions	To measure neuromuscular fatigue: Pmax, Pmean, Vmax, Vmean, CMJ dip, and JH
RSI (drop jump)	Daily pre-session	To measure neuromuscular fatigue: contact time/ contact time. Lower ratio than 1 may indicate fatigue
sRPE	Daily post-session	Compare the level of exertion of the athlete to the intended exertion of the planned session
TL	Weekly	Measure of intensity across a microcycle
Monotony	Weekly	Measure of variation in training across a microcycle
Strain	Weekly	Measure of the product of TL and monotony
Wellness	Ideally every day	Overall health of the athlete: include hours of sleep, sleep quality, soreness, fatigue, and stress
VL	Daily-post session	Measure the contribution of VL based on the type of exercise and category of exercises within the given training season
TI	Daily-post session	Measure the contribution of TI based on the type of exercise and category of exercises within the given training season

Note. CMJ = countermovement jump, RSI = reactive strength index, sRPE = session rated of perceived exertion, TL = training load, VL = volume load, TI = training intensity, Vmax = Maximum velocity, Pmax = Maximum Power, Pmean = Mean power, and JH = Jump Height.

Practical application

This article sought to provide the S&C coach with guidance on how to create a simple and inexpensive monitoring system for fatigue management in athletes. Ideally, the S&C coach should examine the data before (24-48 hours) and after each session, which provides the opportunity to discuss any concerns that may present in the data collected with the athlete for context. Wellness can be completed 2-3 times per week via a simple checklist prior to a session, providing athlete context for how they are feeling and whether any training adjustments are required based on these perceptions. Monitoring with performance tests such as the CMJ and RSI can be completed easily at the beginning of the session at the end of a warm-up to provide insight into their readiness to train. We recommend that the strength and conditioning coach should establish thresholds from baseline specific to their athletes and training location for each assessment monitored, throughout the training day and week to better understand the demands placed on the athlete. It is important to use multiple assessments to monitor athletes as one measurement alone will not provide a holistic picture

regarding the athlete's status. Finally, the interpretation of any monitoring should be individualized and not based on the entire team for context.

AUTHOR CONTRIBUTIONS

FJ conceptually designed the paper and structurally outlined the review and allocated the sections to the authorship team to provide support for each section. All authors contributed equally to this work and support its publication.

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ORIGINAL ARTICLE

The hurdling on home straight in the women 3000m steeplechase

Yuya Maruo . *Department of Physical Education. Tokyo Women's College of Physical Education. Tokyo, Japan.*

ABSTRACT

The 3000m steeplechase is an event in which athletes must clear 28 hurdles and 7 water jumps while competing for the fastest time. In this race, women must clear hurdles set at a height of 0.762 meters, whereas men face hurdles set at a height of 0.914 meters. There is a paucity of research on the 3000m steeplechase compared to other long-distance events. This study aimed to clarify the characteristics of hurdle clearance for the 3000m steeplechase. Investigating how to clear the hurdles on the home straight could significantly enhance race strategies and performance. Data were collected from the women's 3000m steeplechase races at Kanto intercollegiate race. 15 women's performances were analyzed. The 3000m steeplechase races were recorded by video camera. All jumps from participants were digitized using Kinovea (version 0.9.3). I focused on variables of three steps related to the three steps around hurdles, and comparisons were made among each lap. In terms of total clearance speed, we observed that lap4 had a lower speed than lap3, and lap7 had a higher speed than lap4. Before the increase in speed at the hurdle, there was an increase in the length of three steps in lap7. Athletes in the final lap took off from a longer distance and achieved a faster clearance speed. The step frequency before hurdle clearance was higher in lap1 and lap2 than in lap4, lap5, lap6, and lap7. In addition, step frequency after hurdle clearance did not differ among laps and was lower than before hurdle clearance. Fatigue might be a contributing factor to this decline in step frequency before hurdle clearance. It would be advantageous for athletes to consciously increase their step frequency when approaching the next hurdle. The present study provided practical evidence for hurdle clearance of 3000m steeplechase.

Keywords: Performance analysis, Take-off distance, Landing distance, Hurdle clearance.

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Corresponding author. *Department of Physical Education, Tokyo Women's College of Physical Education, 4-30-1, Fujimidai, Kunitachi, Tokyo, Japan.*
E-mail: y-maruo@twcpe.ac.jp
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INTRODUCTION

The 3000m steeplechase is an event in which athletes must clear 28 hurdles and 7 water jumps while competing for the fastest time. In this race, women must clear hurdles set at a height of 0.762 meters, whereas men face hurdles set at a height of 0.914 meters. Previous studies have investigated kinematical, and physiological characteristics of the 3000m steeplechase (Earl et al., 2015; Hanley et al., 2020; Hanley & Williams, 2020; Hunter & Bushnell, 2006; Hunter et al., 2008; Kipp et al., 2017). These studies examined the characteristics of the water jump (Hanley et al., 2020; Hunter & Bushnell, 2006; Hunter et al., 2008; Kipp et al., 2017) and pacing strategies (Hanley & Williams, 2020). However, there is a paucity of research on the 3000m steeplechase compared to other long-distance events.

A few studies have reported hurdling non-water jump in the 3000m steeplechase (Earl et al., 2015; Hunter et al., 2006). Earl et al. (2015) investigated the relationship among variables related to hurdling, such as approach velocity, take-off distance, clearance height, and lead knee extension, running economy and running performance. Their findings suggest that there is no correlation between performance in the 3000m steeplechase and the ratio of running economy. Instead, better performance in the 3000m steeplechase might be associated with factors like VO_{2max}, the ability to change pace, and jump technique. Furthermore, Hunter et al. (2006) reported that the length of two steps around hurdles gradually increases. They did not investigate variables around hurdles, such as approach run distance, time, and speed. To the best of our knowledge, no studies have examined variations in per lap variables for hurdling around non-water jumps.

Many middle- and long-distance races often culminate in a sprint competition during the final laps. Previous studies suggested that for mile race, the last lap was either the fastest or the second fastest in 76% of world record races (Noakes et al., 2009). This pace strategy can also be observed in races such as the 5000m and 10,000m (Aragón et al., 2016; Kirby et al., 2021; Tucker et al., 2006). Likewise, an increase in speed during the final lap has been reported in the 3000m steeplechase (Hanley & Williams, 2020). Since hurdles are placed in the home straightaway in the 3000m steeplechase, it is difficult for athletes to maintain acceleration in final sprint. The key to success lies not only in sprinting when athletes are fatigued but also in executing better hurdling. Investigating how to clear the hurdles on the home straight could significantly enhance race strategies and performance.

This study aimed to clarify the characteristics of hurdle clearance for the 3000m steeplechase. The focus was placed on hurdle clearance on the home straight because athletes may experience fatigue after the water jump, leading to differences in performance compared to other hurdles. Various variables related to hurdling around non-water jumps were measured and compared among each lap. If athletes conserve their energy in the second half of the race, they should be able to maintain nearly constant step length, step frequency, and running speed overlaps. It is important for coaches and athletes to understand how to clear the hurdle, because take-off and landing distances for the hurdle could be influenced by fatigue. Athletes could improve their performance in the 3000m steeplechase by acquiring knowledge and skills about hurdling.

METHODS

Participants

Data were collected from the women's 3000m steeplechase races (final) at Kanto intercollegiate race. 15 women's performances were analysed (mean age ± SD = 20.3 ± 1.3 years). The average finishing time

(min:s) were 10:51.1 ± 21.5. Informed consent was obtained from participants. This study was approved by the Ethics Committee of the Tokyo Women's College of Physical Education (Kenrinsin 2020-03).

Measures

The 3000m steeplechase races were recorded by video camera (CASIO, EXILIM PRO EX-F1). The sampling rate was 300 Hz and the resolution was 512 × 384 px. The 5th hurdle was placed on home straight. The camera was placed to film the athletes from a sagittal view at 5th hurdle on stadium. The camera was zoomed to include 6 m before and 6 m past the hurdle.

The total time for the 3000m steeplechase races were obtained from results documents (The Inter-University Athletic Union of Kanto). All jumps from participants were digitized using Kinovea (version 0.9.3). Each parameter around hurdle were analysed (Figure 1).

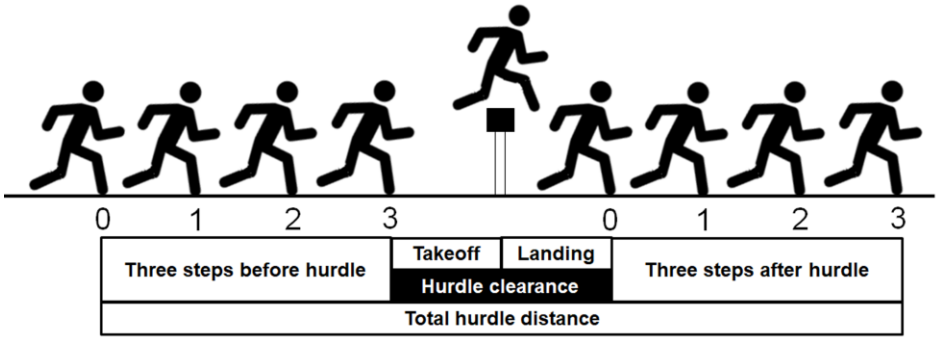

Figure 1. Description for distance of the three steps around hurdle investigated.

Before data collection, I measured 5 m before and 5 m past the hurdle. These measurements were used to create a perspective grid using Kinovea, which made as a reference frame with dimensions of 10 m × 2.5 m. Measures were calculated using Kinovea. We measured the following parameters. Total clearance distance was the horizontal distance from the three steps toe off before hurdle to the three steps toe off after landing. Total clearance time was the total time from the three steps toe off before hurdle to the three steps toe off after landing. Total clearance speed was speed from the three steps toe off before hurdle to the three steps toe off after landing. Take-off distance was the horizontal distance from the take-off toe and front edge of the barrier. Landing distance was the horizontal distance from edge of the barrier to landing toe touching the ground. Clearance distance was the horizontal distance from the take-off toe to landing toe touching the ground. Clearance time was the total time from the take-off toe to landing toe touching the ground. Clearance speed was speed from the take-off toe to landing toe touching the ground.

Distance of three steps before take-off was the horizontal distance from the three steps toe off before hurdle to the take-off. Time of three steps before take-off was the total time from the three steps toe off before hurdle to the take-off. Speed of three steps before take-off was speed from the three steps toe off before hurdle to the take-off toe. Step frequency of three steps before take-off was step frequency from the three steps toe off before hurdle to the take-off toe. Distance of three steps after landing was the horizontal distance from landing toe touching the ground to the three steps toe off after landing. Time of three steps after landing was total time from landing toe touching the ground to the three steps toe off after landing. Speed of three steps after landing was speed from landing toe touching the ground to the three steps toe off after landing. Step frequency of three steps after landing was step frequency from landing toe touching the ground to the three steps toe off after landing. Endpoints of segments were determined by the researchers.

Statistical analysis

Take-off distance, landing distance, clearance distance and clearance time were subjected to one-way ANOVAs with repeated factors of Lap (lap1/lap2/lap3/lap4/lap5/lap6/lap7). Time, length, speed and frequency of three steps around hurdle were subjected to two-way ANOVAs with repeated factors of Lap (lap1/lap2/lap3/lap4/lap5/lap6/lap7) and Around (before/after). Bonferroni correction was applied to post-hoc comparisons. All statistical analyses were conducted using JAPS (0.15.0.0).

RESULTS

Table 1 shows each parameter for the hurdle on the home straight. For total clearance distance, one-way ANOVA revealed that the main effect for lap was significant ($F(6, 84) = 3.41$, $p = .02$, $\eta^2_p = .20$). Post-hoc test revealed that total clearance distance was longer for lap7 than lap4 ($p = .04$). For total clearance time, one-way ANOVA revealed that the main effect for lap was significant ($F(6, 84) = 3.41$, $p = .02$, $\eta^2_p = .20$). Post-hoc test revealed that total clearance time was shorter for lap1 than for lap4 ($p = .01$), lap5 ($p = .01$), lap6 ($p = .01$), and lap7 ($p = .01$). Total clearance time was shorter for lap2 than for lap4 ($p = .03$), lap5 ($p = .02$), and lap6 ($p = .03$). For total clearance speed, one-way ANOVA revealed that the main effect for lap was significant ($F(6, 84) = 3.29$, $p = .03$, $\eta^2_p = .18$). Post-hoc test revealed that total clearance speed was slower for lap4 than lap3 ($p = .05$). Post-hoc test revealed that total clearance speed was higher for lap7 than lap4 ($p = .03$).

Table 1. Parameters from the three steps toe off before hurdle to the three steps toe off after landing. Average (SD).

	Lap1	Lap2	Lap3	Lap4	Lap5	Lap6	Lap7
Total clearance distance (m)	9.87 (0.74)	9.85 (0.98)	10.59 (1.04)	9.83 (1.42)	10.17 (1.06)	9.99 (1.17)	10.74 (0.96)
Total clearance time (s)	2.23 (0.14)	2.29 (0.13)	2.36 (0.10)	2.40 (0.13)	2.41 (0.10)	2.40 (0.10)	2.39 (0.14)
Total clearance speed (m/s)	4.36 (0.24)	4.29 (0.31)	4.48 (0.34)	4.12 (0.69)	4.23 (0.40)	4.17 (0.50)	4.50 (0.45)

Table 2. Parameters for the hurdle clearance. Average (SD).

	Lap1	Lap2	Lap3	Lap4	Lap5	Lap6	Lap7
Take-off distance (m)	0.92 (0.14)	0.93 (0.13)	1.01 (0.14)	0.92 (0.22)	1.01 (0.17)	0.99 (0.16)	1.07 (0.21)
Landing distance (m)	1.29 (0.18)	1.24 (0.26)	1.38 (0.28)	1.28 (0.29)	1.30 (0.28)	1.25 (0.32)	1.31 (0.25)
Clearance distance (m)	2.22 (0.27)	2.22 (0.35)	2.40 (0.35)	2.19 (0.41)	2.30 (0.35)	2.24 (0.36)	2.38 (0.31)
Clearance time (s)	0.53 (0.06)	0.52 (0.07)	0.54 (0.05)	0.55 (0.08)	0.54 (0.06)	0.53 (0.07)	0.53 (0.08)
Clearance speed (m/s)	4.20 (0.60)	4.16 (0.51)	4.46 (0.54)	4.10 (0.90)	4.29 (0.63)	4.26 (0.74)	4.62 (0.88)

Hurdle clearance

Table 2 shows each parameter for the hurdle clearance on the home straight. For take-off distance, a one-way ANOVA revealed that the main effect for lap was significant ($F(6, 84) = 2.82$, $p = .04$, $\eta^2_p = .17$). Post-hoc test revealed that take-off distance was longer for lap7 than lap4 ($p = .04$). For landing distance, a one-way ANOVA revealed that there was no main effect for group ($F(6, 84) = 1.54$, $p = .21$, $\eta^2_p = .10$). For clearance distance, a one-way ANOVA revealed that the main effect for lap was significant ($F(6, 84) = 2.54$, $p = .04$, $\eta^2_p = .15$). Post-hoc test revealed that there was no difference among laps. For clearance time, one-

way ANOVA revealed that there was no main effect for group (F(6, 84) = 0.63, p = .60, η^2_p = .04). For clearance speed, one-way ANOVA revealed that the main effect for lap was significant (F(6, 84) = 3.01, p = .02, η^2_p = .18). Post-hoc test revealed that clearance speed was higher for lap7 than lap4 (p = .02).

Comparison for around hurdle clearance

Table 3 shows time, length, speed and frequency of three steps around hurdle clearance. For three steps length around the fifth hurdle, two-way ANOVA revealed that there was a significant interaction between lap and around hurdle (F(6, 84) = 4.99, p = .01, η^2_p = .26). Post-hoc tests revealed that three steps length for lap1 was longer after hurdle than before hurdle (p = .01). In addition, three steps length before hurdle was longer for lap7 than for lap1 (p = .01) and lap2 (p = .01) and was longer for lap3 than for lap1 (p = .01).

Table 3. Distance, time, speed and step frequency of three steps around hurdle clearance. Average (SD).

	Lap1	Lap2	Lap3	Lap4	Lap5	Lap6	Lap7
Distance of three steps before take-off (m)	3.51 (0.53)	3.60 (0.53)	4.06 (0.59)	3.75 (0.68)	3.86 (0.56)	3.78 (0.60)	4.22 (0.62)
Time of three steps before take-off (s)	0.72 (0.10)	0.74 (0.09)	0.81 (0.10)	0.80 (0.08)	0.81 (0.07)	0.81 (0.07)	0.84 (0.09)
Speed of three steps before take-off (m/s)	4.89 (0.29)	4.85 (0.33)	5.03 (0.34)	4.68 (0.71)	4.76 (0.46)	4.66 (0.54)	5.04 (0.52)
Step frequency of three steps before take-off (Hz)	4.25 (0.50)	4.11 (0.49)	3.78 (0.47)	3.78 (0.37)	3.73 (0.32)	3.74 (0.32)	3.62 (3.67)
Distance of three steps after landing (m)	4.15 (0.30)	4.09 (0.27)	4.14 (0.29)	3.89 (0.51)	4.00 (0.28)	3.97 (0.36)	4.14 (0.35)
Time of three steps after landing (s)	1.02 (0.04)	1.03 (0.03)	1.02 (0.03)	1.05 (0.05)	1.06 (0.04)	1.06 (0.05)	1.03 (0.06)
Speed of three steps after landing (m/s)	4.09 (0.29)	3.97 (0.32)	4.07 (0.29)	3.72 (0.62)	3.80 (0.30)	3.76 (0.41)	4.03 (0.40)
Step frequency of three steps after landing (Hz)	2.96 (0.11)	2.92 (0.09)	2.95 (0.09)	2.86 (0.14)	2.85 (0.09)	2.84 (0.12)	2.92 (0.18)

For time of three steps length around the hurdle, two-way ANOVA revealed there was a significant interaction between lap and around hurdle (F(6, 84) = 3.58, p = .01, η^2_p = .20). Post-hoc test revealed that time of three steps before the hurdle was shorter for lap1 than lap3 (p = .01), lap4 (p = .01), lap5 (p = .01), lap6 (p = .01), and lap7 (p = .01). In addition, time of three steps before the hurdle was shorter for lap2 than lap7 (p = .01). Post-hoc test revealed that time of three steps for all laps was shorter before the fifth hurdle than after the fifth hurdle (ps = .01).

For speed of three steps around the hurdle, two-way ANOVA revealed the main effect for lap was significant (F(6, 84) = 3.33, p = .03, η^2_p = .19). Post-hoc test revealed that speed of three steps tend to be lower lap4 for hurdle than lap3 (p = .08) and speed of three steps tend to be lower lap6 for hurdle than lap3 (p = .09). Two-way ANOVA also revealed the main effect for around hurdle was significant (F(1, 14) = 310.25, p = .01, η^2_p = .95). Post-hoc test revealed that speed of three steps was higher before the fifth hurdle than after the fifth hurdle (p = .01). The interaction between lap and around hurdle was not significant (F(6, 84) = 0.99, p = .41, η^2_p = .07).

For frequency of three steps around the fifth hurdle, two-way ANOVA revealed that there was a significant interaction between lap and around hurdle (F(6, 84) = 5.17, p = .01, η^2_p = .27). Post-hoc test revealed that frequency of three steps length before hurdle was higher for lap1 than for lap3 (p = .01), lap4 (p = .01), lap5

(p = .01), lap6 (p = .01) and lap7 (p = .01) and was higher for lap2 than for lap3 (p = .01), lap4 (p = .01), lap5 (p = .01), lap6 (p = .01) and lap7 (p = .01). In addition, post-hoc test revealed that frequency of three steps was higher before the fifth hurdle than after the fifth hurdle (p = .01).

DISCUSSION

This study aimed to clarify the characteristics hurdle clearance for the 3000m steeplechase. The performances of 15 female athletes were analysed during an intercollegiate race. I focused on variables of three steps related to the three steps around hurdles, and comparisons were made among each lap. In terms of total clearance speed, we observed that lap4 had a lower speed than lap3, and lap7 had a higher speed than lap4. This finding suggests a decline in speed around the hurdles in the middle of the race, likely due to fatigue. Even when athletes were fatigued, they managed to increase their speed at the last hurdle of the final lap. Similarly, for hurdle clearance, we noticed that the take-off distance in lap7 was longer than in lap4. Furthermore, the clearance speed was higher in lap7 than in lap4. Athletes in the final lap took off from a longer distance and achieved a faster clearance speed. Previous studies have suggested that in many middle- and long-distance races, the final laps often become a sprint competition. For instance, Hanley and Williams (2020) investigated pacing profiles in the 3000m steeplechase and found that 27% of the fastest speeds in a women's race were reached in the final home straight. Additionally, previous study has indicated that the last lap was either the fastest or the second fastest in 76% of world record races (Noakes et al., 2008).

The central governor in the human brain has the ability to predict behaviour to avoid exhaustion and regulate exercise performance (Inzlicht & Marcora, 2016; Noakes et al., 2001; St Clair Gibson & Noakes, 2004; Weir et al., 2006). We observed a statistically significant increase in speed during hurdle clearance in lap7. It is plausible that the "*central governor*" plays a pivotal role in controlling exercise performance, allowing athletes to conserve energy for the final sprint. In this study, the increase in clearance speed can likely be attributed to the final sprint and competition just before the finish line.

Before the increase in speed at the hurdle, there was an increase in the length of three steps in lap7. Our results were almost consistent with those from previous studies (Hunter et al., 2006), which suggested that stride length around hurdles gradually increases throughout the race. In this study, we divided the phases around the hurdle and examined step length, time, speed and frequency. I found that the step length was extended before hurdle clearance, while step length after hurdle clearance did not differ among laps. Additionally, we found that the speed of three steps before the hurdle clearance was higher than the average speed of the entire race, whereas the speed of three steps after the hurdle clearance was lower than the average speed of the entire race. The impact of the landing for hurdle clearance may have applied brakes and caused a decrease in speed. In present study, many athletes were hurdling with their legs placed over the hurdles. In addition, previous studies suggested that women tend to be above the hurdle for a longer time (Hunter et al., 2006). Considering these findings, it is beneficial for female steeplechaser to focus on how to increase their speed after clearing hurdle and landing, as this could lead to performance improvement.

In the present study, we found the interaction lap and around hurdle for step frequency. Specifically, the step frequency before hurdle clearance was higher in lap1 and lap2 than in lap4, lap5, lap6, and lap7. Step frequency after hurdle clearance did not differ among laps and was lower than before hurdle clearance. These findings suggest that the influence of the lap was only evident before hurdle clearance. In the first and second laps, athletes approached the hurdles with a higher step frequency. However, from the third lap onwards, step frequency before hurdle clearance gradually decreased. Fatigue might be a contributing factor to this

decline in step frequency before hurdle clearance. Therefore, it would be advantageous for athletes to consciously increase their step frequency when approaching the next hurdle.

Athletes competing in the 3000m steeplechase need to master two hurdling techniques for water jumps and non-water jumps. Although the hurdle height is the same, the required techniques may differ. Emphasizing the pushing motion is essential when jumping from a water pit (Hanley et al., 2020), as fatigue can lead to a shorter landing distance. Moreover, a shorter landing distance for the water jump can make it more difficult for athletes to exit the water pit (Maruo, 2023). Therefore, prioritizing a longer landing distance during hurdle clearance in water jumps can be beneficial. Conversely, in the non-water jumps investigated in this study, increasing step frequency is crucial to maintain speed around the hurdle clearance. Around hurdle clearance, athletes should focus on raising their step frequency to prevent a decrease in speed. Given that there was no main effect for laps on step length, athletes should concentrate on avoiding a reduction in pitch for non-water jumps.

Previous studies have suggested that better performance in the 3000m steeplechase might be associated with factors such as VO_{2max}, strength, the ability to change pace, and jump technique (Earl et al., 2015; Gabrielli et al., 2015; Maruo 2023). Fartlek training could be a valuable method to target changes in step frequency. Fartlek training involves athletes alternating between moderate and high speeds during repeated runs, typically performed in cross-country or forest settings. Considering that our results have shown a statistically significant difference before and after hurdle clearance, training that emphasizes the simple technique of increasing step frequency around hurdle clearance could potentially enhance performance in the 3000m steeplechase.

CONCLUSIONS

In sum, total clearance speed was lower for lap4 than lap3, and was higher lap7 than lap4. This finding suggests a decline in speed around the hurdles in the middle of the race, likely due to fatigue. Before the increase in speed at the hurdle, there was an increase in the length of three steps in lap7. In addition, we found the interaction lap and around hurdle for step frequency. Specifically, the step frequency before hurdle clearance was higher in lap1 and lap2 than in lap4, lap5, lap6, and lap7. After hurdle clearance, step frequency did not differ among laps. Fatigue might be a contributing factor to this decline in step frequency before hurdle clearance. Around hurdle clearance, athletes should focus on raising their step frequency to prevent a decrease in speed. The present study provided practical evidence for hurdle clearance of 3000m steeplechase.

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SCIENTIFIC JOURNAL OF SPORT AND PERFORMANCE

REVIEW ARTICLE

Personality traits and exercise modes: Review article

Patrícia Filipa Saraiva de Sousa . *Polytechnic Institute of Viseu – Higher Education School of Viseu. Viseu, Portugal.*

ABSTRACT

Over the last few decades, Physical Exercise has been touted as one of the most important behavioural health practices. Personality has been considered a predictive variable for the adoption of behaviours such as involvement in Physical Exercise programs. Therefore, this study analysed the relationship between personality and the choice of exercise modes. The literature suggests the need to investigate more on this topic. In the analysed studies, no statistically significant differences were found between personality profiles and exercise modes practiced. However, differences were found between personality profiles and aspects related to the context in which the exercise is practiced, such as intensity, space and place where they practice, whether they practice alone or accompanied and with or without the assistance of a professional. The results obtained need not only more investigation, but also need to cover more aspects related to the exercise modes practised.

Keywords: Physical exercise, Personality traits, Personality profiles, Physical exercise modes.

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Corresponding author. *Polytechnic Institute of Viseu – Higher Education School of Viseu. Praceta da Colina Verde Nº8 3º Direito 3510-141 São Salvador, Colina Verde. Viseu 969676850; Portugal.*
E-mail: psousa@esev.ipv.pt
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INTRODUCTION

Regular Physical Exercise (PE) is an effective means to reduce the risk of morbidity and mortality, also showing generalized improvements in physical and mental health (Box, Feito, Brown and Petruzzello, 2019).

In recent decades, there has been a lot of evidence that PE is important to decrease the risks associated with metabolic diseases, osteopathic diseases, cardiovascular diseases, neurovascular diseases, as well as some types of cancer (Box et al., 2019). In addition, evidence suggests that greater PE behaviour is related to reduced levels of anxiety, depression symptoms, and stress-related disorders (Arem, Moore, Patel, Hartge, Gonzalez, Visvanathan and Linet, 2015; Box et al., 2019).

Despite the benefits that have been proven over the years in health promotion, the number of individuals who practice any form of PE is extremely low (Troiano, Berrigan, Dodd, Masse, Tilert and McDowell, 2008). Tucker, Welk and Beyler (2011) add that less than 20% of the world's population practices enough PE to obtain any health benefits. Women and elderly people living in developed countries are at higher risk of physical inactivity (Hallal, Andersen, Bull, Guthold, Haskell, Ekelund and Wells, 2012; Sallis, Bull, Guthold, Heath, Inove, Kelly, Oyeyemi, Perez, Richards and Hallal., 2016).

With the world's population aging rapidly, there is an emerging need to focus efforts to promote and encourage an active lifestyle (Karvonen, Törmäkangas, Pulkkinen and Kokko, 2020). Thus, a strong theoretical understanding of the factors associated with PE is warranted in order to create effective and targeted interventions. This has been a concern in recent decades, and interventions aimed at increasing EF have been promising in public health (Lachman, Lipsitz, Lubbon and Castaneda-Sceppa, 2018; WHO, 2018). To optimize the effectiveness of such interventions, factors/barriers to the adoption of active lifestyles must be taken into account and the receptivity of individuals to change. These factors include not only an individual's state of health, or the social and environmental context, but also psychological factors such as personality traits (Bauman, Reis, Sallis, Wells, Loos and Martins, 2012). Personality traits are associated with engagement in, or abstinence from, health behaviours that affect health across the lifespan (Friedman, 2000). The concept of trait refers to a stable characteristic, which makes individuals behave in specific ways in different situations. The combination of several personality traits allows indicating the individual's personality profile (AAP, 2018).

In recent decades, the relationship between personality profiles and the practice of PE has been the subject of considerable research, with the intention of understanding whether the personality profile influences an individual's adherence to PE behaviours (Allen and Laborde, 2014).

In the personality approach, one of the most used models is the 5-profile model presented by McCrae and John (1992), also called "*Big Five*" or "*Five Factor Model*" (Box et al, 2019; John and Srivastava, 1999; McCrae and Costa, 1987; Rhodes and Boudreau, 2017). These 5 profiles are related to traits that generally define the person (McAdams , 1992), which are: Neuroticism, which corresponds to the tendency towards a negative emotional state, anxious, self-conscious and vulnerable, therefore, they are nervous, pessimistic individuals and easily disturbed; Extroversion, which is the propensity to be gregarious, assertive and seek excitement, these individuals are talkative, sociable, assertive and energetic; Conscience, which is the inclination to be orderly, obedient, self-disciplined, and achievement-oriented, these being cooperative, responsible, reliable, good-natured individuals; Openness to Experience, which corresponds to the tendency to be perceptive, creative, reflective and aesthetic, therefore being intellectual and imaginative people;

Kindness, which is associated with the tendency to be kind, cooperative, friendly and trustworthy, these individuals are warm, with good nature (Box et al., 2019; Rhodes and Smith, 2006).

This model makes it possible to group individuals according to their individual characteristics, which influence their behaviour. As such, over the last few decades, several studies have proven the relationship between personality profiles and PE behaviour (Rhodes and Smith, 2006). In this follow-up, the objective of the present study is to investigate the relationship between personality profiles and the choice of practiced PE modes. Clarifying this relationship could be an added value in the development of PE promotion programs, enhancing the involvement and adherence of individuals with them, thus expecting a healthier life. Table 1 presents a summary of the main articles that study the topic under analysis.

Table 1. Relationship between personality profiles and PE behaviour.

Article	Sample	Instruments	Results	Conclusions
Courneya And Hellsten, (1998)	N=264 university students; 62% female; 21.3±3.0	NEO FFi (Personality); Questions drawn from a survey by Stephens and Craig (1990) for PE preference	1 - Extroverts: prefer to train in a group; supervised training. 2 – Openness to Experience: they prefer to exercise outdoors; higher scores in walking/running and lower in skating; lower scores for supervised, scheduled exercise; higher scores for recreational exercise and lower scores for competition. 3 – Kindness: higher scores in aerobics and lower in bodybuilding; higher scores in recreational exercises and lower in competition. 4 - Conscious: prefer programmed and high-intensity exercises; 5 – Neurotics: prefer lower intensity exercises.	- Possibly the main characteristics of an activity have less to do with the activity itself and more to do with the context in which the activity takes place (e.g. alone *vs.* in a group; low intensity *vs.* high intensity).
Hagan And Hausenblas, (2005)	N=507 university students; 52.3% male; 21.27 ±9.76	NEO Pi-R (Personality – extended version); 9 questions similar to those used by Courneya and Hellsten (1998) for PE preferences.	Significant differences for personality domains and exercise intensity preferences; company (alone *vs.* accompanied); training space/place. There were no significant differences for the type of exercise (cardiovascular *vs.* weight training). 1 – Extroversion: higher scores in high-intensity exercise; group training; in a mixed gym; 2 – A. Experience: higher scores in high-intensity exercise. 3 – Awareness: higher scores for high-intensity exercise; in mixed gym. 4 – Neuroticism: they prefer to train alone, ideally at home.	- Information obtained about preferences and personality domains can be used in PE prescriptions to increase the likelihood of participation and adherence.
Box, Feito, Brown And Petruzzello, (2019)	N=403 adults; 35.5% male; 36.3 ±11.6	Big Five Inventory (Personality); Questions related to the participants' primary modes of PE.	Controlling for age and sex differences, no significant differences were found in personality profiles as a function of primary PE modes.	- There is uncertainty about how the 5 personality profiles might relate to PE mode.

Source: Own elaboration

DISCUSSION

The literature review did not allow finding significant differences between personality profiles and exercise modes (see table 1). Regarding this result, it is important to point out that both the population used for the sample (university students, mean age ± 21 years) and the instruments (*NEO* short and extended version, respectively) used in the first two studies are different from those used in the third study (adults, mean age ± 37 years; *Big Five Inventory*).

Box et al. (2019) justify these results by arguing that individuals, regardless of the primary mode of exercise they practice, are physically active and may have similar personalities. This justification raises some disagreement in the literature, as for Pacheco and Sisto (2003) traits are personality tendencies and are immutable. However, Sisto and Oliveira (2007) share the opinion of Costa and McCrae (1992) and state that these personality tendencies are relatively stable in the way of thinking, feeling and acting with people, characterizing, however, possibilities for changes, such as product of people's interactions with their social environment. Therefore, it is an open question and it is important to clarify.

Courneya and Hellsten (1998) refer that these results indicate that it may be the characteristics, the involvement of the modalities that relate to the personality and not the activity itself. Regarding the intensity of the exercise (high/low intensity), the space where it is performed (home/gym), whether it is done alone or with a partner, the type of instruction (with a professional/self-directed) and the location (outdoor/indoor), the studies by Courneya and Hellsten (1998) and Hagan and Hausenblas (2005) are in line. Individuals with high scores on Extroversion, Conscientiousness, and Openness to Experience tend to prefer moderate and vigorous intensity exercise, whereas those with high anxiety scores on Neuroticism prefer lower intensity exercise. The latter also tend to choose to exercise alone, without supervision, ideally at home.

Individuals with high scores on Extroversion and Conscientiousness prefer to train in a group, with supervision, ideally in the gym. Therefore, the findings made in both studies help to understand some aspects about the context in which individuals prefer to exercise due to their personality. Such information should be taken into account when creating PE intervention/promotion programs and combating abandonment.

As for the mode of exercise, it will still be important to clarify a few more questions: in the first article (Courneya and Hellsten, 1998), the sample participants answered questions about their preference for PE, making it possible to perceive, for example, that individuals with high in Openness to Experience prefer walking to skating; high scorers on Agreeableness prefer aerobics to strength training. However, in the second article (Hagan and Hausenblas, 2005), although the sample participants also answered questions about exercise preference, the options were only cardiovascular training and weight training, which seems to be somewhat limiting when there is a wide range of options. Bunch of options. In the third article (Box et al., 2019) individuals were grouped according to the primary mode of exercise they practiced. This division of groups raises some doubts, for example, *CrossFit* is a modality practiced in a group, with a competition aspect, how can one justify the non-inclusion of these practitioners in the sport/competition group, or in group training, or in aerobic training? This lack of clarification may have affected the results or made their analysis more difficult.

Hagan and Hausenblas (2005) and Box et al. (2019) suggest that gaining more information about potential individual differences and PE preferences may contribute to more optimal PE prescriptions and contribute to increasing the likelihood of participation and adherence.

Therefore, it is clear that, on this subject, there is still much to be clarified, strengthening the idea that it is necessary to investigate further and expand the field of investigation. The effectiveness of behaviour change interventions, implementation of PE practice, may depend on individual differences and can be improved when personality is taken into account (Stiegger, Robinson, Bisson and Lachman, 2020).

CONCLUSIONS

Personality profiles have been associated with the adoption of certain behaviours, such as a tendency towards physical inactivity, or, on the other hand, involvement and adherence to the practice of PE. In the present study, we investigated the possible responsibility of personality profiles in the choice of practiced exercise modes. Through the existing literature it was possible to verify that there are no statistically significant differences between the personality profiles and the exercise modes practiced. However, it was found that personality profiles influence certain aspects related to the context of exercise practice, such as the place of practice, whether individuals prefer to train alone or with others and the intensity of exercise. It is important to clarify these results, to broaden the field of research on this subject, covering different modes of exercise and different contexts associated with the practice, in order to obtain more concrete conclusions.

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ORIGINAL ARTICLE

Analysing factors impacting Bangladesh men's T20 cricket performance

Anamul Haque Sajib. *Department of Statisitcs. University of Dhaka. Dhaka, Bangladesh.*
Shakib Hasan Limon. *Department of Statisitcs. University of Dhaka. Dhaka, Bangladesh.*
Adiat Ibn Naser. *Department of Statisitcs. University of Dhaka. Dhaka, Bangladesh.*
Goutam Saha ✉ **.** *Department of Mathematics. University of Dhaka. Dhaka, Bangladesh.*

ABSTRACT

Over the past decade, the T20 cricket format has witnessed a remarkable surge in popularity within the cricketing community. While top-tier teams such as England, Pakistan, Australia, India, and South Africa have embraced this format with ease, others like Bangladesh, Afghanistan, Zimbabwe, and Sri Lanka are facing challenges in adapting to it. This study seeks to identify the key factors influencing the performance of the Bangladesh men's cricket team, utilizing data sourced from ESPNcricinfo. The binary logistic regression model is considered to analyze the data as the response variable is binary (match won or lost). Examining the output of the binary logistic regression, it becomes evident that factors such as 'Location' (the venue where a match took place), 'Most Wickets' (wherein at least one player took 3 or more wickets), and 'One-Digit Score' (signifying scenarios where less than 3, 3 to 6, or more than 6 batsmen scored in the one-digit range) exhibit notable and statistically significant effects on team performance. Notably, variables such as the inclusion of Shakib Al Hasan and the Five Pillars (the concurrent presence of Mashrafe Bin Mortaza, Tamim Iqbal, Shakib Al Hasan, Mushfiqur Rahim, and Mahmudullah Riyad) do not demonstrate any substantial impact on the team's performance. These research findings hold the potential to inform strategic planning aimed at enhancing the Bangladesh men's cricket team's performance.

Keywords: Performance analysis, T20 performance, Bangladesh men's cricket team, ESPNcricinfo data, Binary logistic regression, Performance factors.

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✉ **Corresponding author.** *Department of Mathematics. University of Dhaka. Dhaka-1000, Bangladesh.*
E-mail: gsahamath@du.ac.bd
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INTRODUCTION

Cricket, a sport played both indoors and outdoors using a bat and a ball, holds a paramount position as the most cherished and significant sport in Bangladesh (Subhani et al., 2012). The playing area, known as the pitch, is centrally located within a field. Within the framework of specific rules and regulations, a contest unfolds between two teams, each comprising 11 players who take turns in batting and bowling/fielding (Perera, 2015; Singh et al., 2015; Stuelcken et al., 2007). Three different formats are used to play cricket both internationally and domestically, which makes it unique (Petersen *et al*., 2011, Sloane, 2020). These formats include everything from lengthy, multiday Test matches to quick 50 over One-day games and T20 play. The distinct skill sets needed for various formats of cricket are evident through the distinct team compositions chosen for each format in professional cricket (Sloane, 2020). Among these formats, Test cricket stands out as the longest version and is universally acknowledged by coaches, players, and enthusiasts as the ultimate assessment of playing prowess (Wicktramasinghe, 2014, Sloane, 2020). Furthermore, Test cricket is commonly recognized as the zenith of the sport (Peterson et al., 2011; Sloane, 2020). In 1877, during an England tour of Australia, two matches were played against full Australian XIs that are now historically recognized as the inaugural Test matches. The inception of one-day cricket took place in the 1960s, representing a variation of the sport characterized by limited overs, with each side having 50 overs to play (Perera et al., 2015, Sloane, 2020). ODI cricket was introduced as a means to reduce the occurrence of drawn matches and to infuse more excitement into the game through a more aggressive style of batting (Swartz et al., 2006, Sloane, 2020). Subsequently, T20 cricket was introduced with the aim of enhancing the attendance and engagement of contemporary spectators (Singh et al., 2015, Sloane, 2020). The inaugural international T20 match unfolded on June 13, 2005, pitting England against Australia at Hampshire's Rose Bowl. T20 cricket is primarily oriented towards entertaining spectators rather than being a strategic contest of planning and execution (Subhani et al., 2012, Sloane, 2020).

Bangladesh made their T20 International (T20I) debut against Zimbabwe in 2006, initially grappling with the challenges posed by more seasoned teams. Nevertheless, a significant turning point arrived when they clinched their inaugural T20I victory against Scotland during the ICC World T20 in 2007. Over time, Bangladesh began to carve a niche for themselves in the competitive T20 arena, notching up wins against several established cricketing nations. Their spirited displays contributed to a more well-rounded team. In 2014, Bangladesh co-hosted the ICC World T20 with India and managed to progress to the Super 10 stage but couldn't advance further. The 2016 ICC World T20 in India saw Bangladesh deliver a mixed performance. They secured a victory against Oman in the qualifying round but couldn't break through the Super 10 stage. Notably, they have demonstrated their potential by defeating top-ranked teams such as India, Pakistan, and South Africa on multiple occasions.

In Sloane's (2020) report titled "*Analysis of Performance Indicators in IPL Twenty20 Cricket from 2015 to 2017*," data were collected from the reputable source Statsguru, which serves as ESPN Cricinfo's cricket statistics database. The data underwent analysis utilizing the SAS statistical software (SAS, 2017). The dataset was subsequently split into two categories based on whether the team batted first or second. The match outcome was treated as a binary variable, encompassing only win-or-lose results, with drawn matches excluded from the study. To investigate the connection between potential predictor variables and the match outcome, univariate logistic regression was carried out. Each predictor variable was individually incorporated into the model to evaluate its influence on the match result. The statistical significance of each predictor variable was assessed through an exact test, specifically an exact conditional logistic regression, and the resulting precise *p*-values were documented. The entire analysis was executed using the SAS procedure LOGISTIC. In a separate study titled "*IPL Team Performance Analysis: A Multi-Criteria Group Decision*

Approach in a Fuzzy Environment," authored by Dey et al. (2015), data were gathered from the primary dataset available through open sources, covering the six-year period from 2008 to 2013 within the Indian Premier League (IPL). The objective of this report was to assess team performances over the initial six IPL seasons, with a focus on the domain of sports data mining.

In the field of literature, Kimber (1993) introduced a graphical technique for evaluating and contrasting bowlers' performances. Expanding upon this work, Van Staden (2009) introduced another graphical approach specifically designed for comparing the bowling and batting performances of cricketers. This methodology has proven effective in distinguishing various player archetypes, including aggressive batsmen, versatile bowlers, and other notable categories. Dey et al. (2011) put forward a multi-faceted decision-making approach for appraising bowlers' performances within the context of the Indian Premier League. This approach is likely to offer a more comprehensive and nuanced analysis compared to purely graphical methods. Additionally, Barr and Kantor (2004) proposed a mathematical technique for evaluating and selecting batsmen in the sport.

A profound understanding of performance indicators in T20 matches is essential for effective player management and strategic planning in both individual games and tournaments. Coaches and players can gain valuable insights into the impact of various performance variables on match outcomes, enabling them to implement winning strategies. This study aims to provide players and coaches with a deeper comprehension of the factors influencing positive results in matches and tournaments through data collection and analysis.

The study focuses on unravelling the intricate relationship between different aspects of cricket performance and team outcomes in the T20 format for the Bangladesh team. It investigates factors like match location and timing to determine if elements such as home-ground advantage or specific time slots influence their success. Additionally, the study delves into batting performance variables to highlight the importance of not only the team's overall run tally but also individual batsmen's roles and the strategic decision of batting first. In the domain of bowling performance, the study aims to assess how effectively the bowlers' wicket-taking abilities contribute to the team's victories or defeats. Ultimately, this comprehensive analysis aims to offer a holistic understanding of the factors shaping the Bangladesh cricket team's performance in T20 matches, providing valuable insights for cricket enthusiasts and strategists.

METHODOLOGY

Data and variables

The Bangladesh National Team has participated in a total of 142 T20 matches since 2006. Due to the relatively limited number of T20 matches played by the Bangladesh national team, all 142 matches have been considered as in our dataset. Within this dataset, we have a single dependent variable referred to as 'response.' The 'response' variable signifies the match outcome, distinguishing between a win (1) and a loss (0).

Our study incorporates eleven explanatory variables, all of which are categorical.

The first explanatory variable, 'Location,' identifies the match's location, categorized into three options: '0' for matches played at home, '1' for matches played in Asian countries other than Bangladesh, and '2' for matches played in countries outside Asia.

The second explanatory variable, 'Time,' contains two categories, representing whether the match occurred during the daytime (0) or nighttime (1).

We also consider the presence or absence of Shakib Al Hasan, a prominent all-rounder, as an independent variable ('Shakib'). If Shakib played, it is denoted as '1,' and if not, it is '0.'

The 'Five Pillars' explanatory categorical variable reflects the participation of the five key players, Mashrafe Bin Mortaza, Tamim Iqbal, Shakib Al Hasan, Mushfiqur Rahim, and Mahmudullah Riyad together. It takes on '1' when all five members were present and '0' if at least one member was absent during the match.

The 'Captain' variable indicates the captaincy role during the match, with '0' for Mahamudullah, '1' for Mashrafeee, '2' for Shakib, and other Bangladeshi players.

'Batting First' is the sixth explanatory variable, indicating whether Bangladesh batted in the first innings (1) or the second innings (2).

The 'Score' independent variable categorizes matches into '0' if Bangladesh scored 150 runs or less and '1' if they scored more than 150 runs.

'One Digit Score' has three categories: '0' for matches where fewer than 3 batsmen scored one-digit runs, '1' for matches with 3 to 6 batsmen scoring one-digit runs, and '2' for matches with more than 6 batsmen scoring one-digit runs.

The 'Most wicket' qualitative independent variable indicates whether at least one bowler took 3 or more wickets (1) or not (0).

The 'Thirty-plus run' variable signifies whether at least two players scored thirty-plus runs (1) or not (0).

Lastly, the 'Boundaries' variable distinguishes matches where Bangladesh scored 20 or fewer boundaries (0) from those where they scored more than 20 boundaries.

Study variables

Table 1 displays the dependent and independent variables used in this study, along with their respective categories.

Table 1. Dependent and independent variables along with categories.

Level of Variables
Dependent Variable
Response (0: Lose, 1: Win)
Independent Variables
Location (0: Home, 1: Asia, 2: Other)
Time (0: Day, 1: Night)
Shakib (0: Absent, 1: Present)
Five Pillars (0: Absent, 1: Present)
Captain (0: Mahmudullah, 1: Mashrafee, 2: Shakib, 3: Others)
Bat First (0: No, 1: Yes)
Score (0: Match score equal or less than 150, 1: Match score more than 150)

One-digit score (0: Less than 3 batsmen scored 1 digit, 1: One digit scored by 3 to 6 batsmen, 2: More than 6 batsmen scored one digit)
Most wickets (1: At least 1 player has taken 3 or more wickets, 0: Otherwise)
Thirty plus run (1: At least 2 players scored 30+ runs, 0: Otherwise)
Boundaries (0: Boundaries scored less than 20, 1: Boundaries scored more than 20)

Method of data collection

Bangladesh has been actively participating in T20 matches since 2006. Our research encompasses data collected from every T20 match played by the Bangladesh National Team spanning the years 2006 to 2023. All the data utilized in this study has been sourced from the ESPNcricinfo website, which is renowned for maintaining comprehensive match data, including live ball-by-ball commentary. ESPNcricinfo is widely recognized as a dependable source, trusted not only within professional cricket but also referenced by numerous published authors.

Data processing

Following the input of data from ESPNcricinfo, the dataset underwent comprehensive analysis through the utilization of IBM SPSS Statistics software. All pertinent characteristics within the dataset were scrutinized, organized, summarized, and assessed in accordance with the goals of the research.

Statistical analysis

In our analysis, we conducted a descriptive statistical analysis of the study variables, utilizing frequencies and percentages to elucidate their characteristics. To explore the connection between categorical outcomes and categorical explanatory variables, we applied either the Pearson Chi-Square test or Fisher's exact test. Furthermore, Binary Logistic Regression was employed as a part of our analytical approach.

Univariate analysis

Since all variables considered in this study are categorical variables, we calculated the frequency and percentage distribution of each covariate.

Bivariate analysis

To examine how the response of the match (win or lose) changes with the change of category of each covariate we considered, we used the Pearson Chi-square test.

The hypothesis in bivariate analysis can be formulated as:

H_0: There is no association between the selected covariate and the outcome variable. H_a: There is an association between the selected covariate and the outcome variable.

The Chi-square test statistic can be defined as:

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij} - E_{ij})^2}{E_{ij}},$$

where O_{ij}= The number of observations in the cell (i, j); $i = 1,2,3 \ldots, r, j = 1,2,3, \ldots, c$; E_{ij}: Expected cell values. The test statistic follows a Chi-squared distribution with $(r-1) * (c-1)$ degrees of freedom. The *p*-value collected from this test is used to make the decision.

Logistic regression

Logistic regression is a statistical analysis method of modelling the probability of a discrete outcome given input variables. The formula of logistic regression can be written in a linear equation form:

$$\ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k,$$

where p=Pr(Y=1) and $\beta_0, \beta_1, \beta_2, \ldots, \beta_k$ are the regression coefficients and $X_1, X_2, \ldots, X_k$ are explanatory variables. Solving for probability equation result in:

$$p = \Pr(Y = 1) = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k)}}$$

Binary logistic regression

The most popular type of logistic regression model is an outcome that can only have one of two possible values, such as yes or no, win or lose, true or false, and so on. The response variable can only fall into one of two categories in binary logistic regression.

Issues during data collection

Manual data collection from websites can prove to be a laborious endeavour, particularly when grappling with substantial datasets or the need to extract information from numerous web pages. The complexity intensifies as websites frequently present data in assorted formats, creating hurdles in the seamless standardization and integration of data into statistical analysis tools like SPSS. Moreover, the reliability of web-sourced data can be compromised as certain websites might lack comprehensive information or omit vital variables, such as runs and the number of wickets fallen during the power play, thereby limiting the depth of analysis. Additionally, manual data entry is susceptible to human errors, encompassing typographical mistakes and misinterpretation of data, which, in turn, can undermine the precision and trustworthiness of subsequent analyses.

RESULTS AND DISCUSSION

Univariate analysis

In this section, we have evaluated the data by examining each variable separately, which is the simplest form to analyse the data. To do this, we have used a univariate Table 2 to display the frequency distributions and corresponding percentages of our explanatory variables as well as the response variable.

Table 2. Percentage and frequency distribution of variables with different categories.

Variable	Frequency	Percentage	Valid Percentage
Response			
Win	55	38.7	38.7
Lose	87	61.3	61.3
Location			
Home	60	42.3	42.3
Asia	35	24.6	24.6
Other	47	33.1	33.1
Time			
Day	64	45.1	45.1

Night	78	54.9	54.9
Shakib			
Present	33	23.2	23.2
Absent	109	76.8	76.8
Five pillars			
Present	116	81.7	81.7
Absent	26	18.3	18.3
Captain			
Mahmudullah	39	27.5	27.5
Mashrafe	24	16.9	16.9
Shakib	37	26.1	26.1
Other	42	29.6	29.6
Bat First			
No	71	50	50
Yes	71	50	50
Score			
<150	90	63.4	63.4
>150	52	36.6	36.6
One Digit score			
<3 players	48	33.8	33.8
3 to 6 players	54	38	38
>6 players	40	28.2	28.2
Most wicket			
At least 1 player has taken 3 or more wickets	9	6.3	6.3
otherwise	133	93.7	93.7
Thirty plus run			
At least 2 players scored 30+ runs	15	10.6	10.6
otherwise	127	89.4	89.4
Boundaries			
Boundaries scored less than 20	114	80.3	80.3
Boundaries scored more than 20	28	19.7	19.7

The Bangladesh cricket team has participated in a total of 142 T20 matches, winning 55 of them, which translates to a winning percentage of 38.7%. Conversely, their losing percentage stands at 61.3%. Bangladesh team has played most of their matches in their home country which is 42.3% of the total matches while 24.6% of the matches have been played within Asia (outside Bangladesh) which is the lowest.

Out of the 142 matches, 78 took place during nighttime, while 45.1% were daytime fixtures. This indicates that Bangladesh played 9.8% more T20 matches in nighttime conditions.

The "*5 pillars*" of the Bangladesh cricket team, comprising Tamim Iqbal, Shakib Al Hasan, Mushfiqur Rahim, Mashrafe, and Mahmudullah, collectively featured in only 26 out of the 142 matches. In a majority of the T20 matches, at least one member of this quintet was absent, accounting for 81.7% of the games. Conversely, all five players were present in a mere 18.3% of the matches.

Mashrafe held the position of team captain in the lowest proportion of matches, accounting for just 16.9%. In contrast, Shakib and Mahmudullah led the team in 26.1% and 27.5% of the matches, respectively. Notably, Bangladeshi players other than Mashrafe, Shakib, and Mahmudullah assumed the captain's role in the highest proportion of matches, totalling 29.6% within the group.

In half of the T20 matches, the Bangladesh squad took to the crease for the 1st innings, while the remaining 50% saw them batting in the 2nd innings. In 90 out of the 142 matches, the Bangladesh team's scores fell below the 150-run mark, signifying a rate of 36.6%. Conversely, in 36.6% of the matches, the Tigers managed to amass more than 150 runs.

In the lowest percentage of T20 matches, which amounts to 28.2%, more than six players scored in single digits. In 54 matches, which is 38% of the total, three to six players registered single-digit scores. Finally, in 33.8% of the matches, fewer than three Bangladeshi players scored in single digits.

In a mere 9 T20 matches, there was the presence of at least 1 Bangladeshi bowler who managed to secure 3 or more wickets. This occurrence constituted just 6.30% of all matches. Conversely, a significant majority of matches, precisely 93.7%, did not witness any bowler achieving 3 or more wickets.

In 15 matches, at least 2 players scored 30+ runs, reflecting a rate of occurrence of 10.6%. Conversely, in 89.4% of the matches, fewer than 2 players struggled to reach the 30-run mark.

The Bangladesh team successfully notched up more than 20 boundaries (comprising 4's and 6's) in 19.7% of the matches. In contrast, in the majority of T20s, specifically 80.3% of them, which amounts to 114 matches, the Bangladesh squad fell short of this boundary count.

Bivariate analysis

In this section, we conducted a bivariate analysis to examine the relationships between our independent variables and the match result. To achieve this, we initially created a bivariate Table. Significant associations can be discerned from the *p*-values presented in Table 3. Table 3 displays the frequencies and percentages of various explanatory variables along with their corresponding *p*-values.

The analysis revealed that the 'Location,' 'Score,' 'One-digit score,' 'Most wicket,' '30+ run,' and 'Boundaries' variables significantly influence the match outcome, as their respective *p*-values are less than the threshold $\alpha = .05$.

Furthermore, Table 3 indicates that no significant associations exist between the timing of the match, the presence of Shakib, the presence of the five key players (i.e., Tamim, Shakib, Mushfique, Mahamudullah, Mashrafe), the captaincy, and batting during the first innings.

Table 3 shows that response (i.e. win or lose) differs by the place where the game was played. The home ground plays a significant role in the chance of winning or losing.

In instances where the match was played away from home, the winning percentage experiences a decline. This observation is underscored by the low *p*-value of .001, further highlighting the significance of this trend. When Bangladesh's score falls below 150, they secure victory in only 31.1 percent of the matches. Conversely, this figure rises to 51.9 percent when they score above 150. Our statistical significance test

corroborates this finding, as the *p*-value of .012 is less than the threshold α = .05. Therefore, this conclusion holds significance at the 5% level of significance.

Table 3. Percentage and frequency distribution of variables with different categories of selected covariates along with *p*-values.

Explanatory Variables	Win	Lose	*p*-value
Location			
Home	33 (55%)	27 (45%)	
Asia	10 (28.6%)	25 (71.4%)	.003**
Other	12 (25.5%)	35 (74.5%)	
Time			
Day	21 (32.8%)	43 (67.2%)	.227
Night	34 (43.6%)	44 (56.4%)	
Shakib			
Present	44 (40.4%)	14 (53.8%)	.505
Absent	11 (33.3%)	73 (62.9%)	
5 Pillars			
Present	12 (46.2%)	14 (53.8%)	.505
Absent	43 (37.1%)	73 (62.9%)	
Captain			
Mahmudullah	14 (35.9%)	25 (64.1%)	
Mashrafee	10 (41.7%)	14 (58.3%)	.963
Shakib	14 (37.8%)	23 (62.2%)	
Other	17 (40.5%)	25 (59.5%)	
Bat First			
No	24 (33.8%)	47 (66.2%)	.301
Yes	31 (43.7%)	40 (56.3%)	
Score			
<150	38 (31.1%)	62 (68.9%)	.012*
>150	27 (51.9%)	25 (48.1%)	
One Digit score			
<3 players	30 (62.5%)	18 (37.5%)	
3 to 6 players	19 (35.2%)	35 (64.8%)	0***
>6 players	6 (15.0%)	34 (85.0%)	
Most wicket			
At least 1 player has taken 3 or more wickets	8 (88.9%)	1 (11.1%)	.002**
otherwise	47 (35.3%)	86 (64.7%)	
Thirty plus run			
At least 2 players scored 30+ runs	10 (66.7%)	5 (33.3%)	.025*
otherwise	45 (35.4%)	82 (64.6%)	
Boundaries			
Boundaries scored less than 20	39(34.2%)	75(65.8%)	.031*
Boundaries scored more than 20	16(57.1%)	12(42.9%)	

*Note. *p < .05, **p < .01, ***p < .001.*

Furthermore, the match outcome is influenced by the number of players who score in single digit. As the count of players scoring in single digit increases, the winning percentage declines. For example, when fewer than 3 players score in single digits, the team wins 62.5% of the matches. When the count exceeds 3 but remains below 6, the winning percentage drops to 35.2%, and when it surpasses 6, it diminishes further to 15%. Additionally, the *p*-value is 0, indicating a highly significant relationship at the 5% level of significance.

It is evident that the number of wickets taken by a single bowler also affects the match outcome. The higher the wicket count, the greater the likelihood of winning. When at least one player takes 3 or more wickets, the team wins in 88.9% of cases. The *p*-value is .002, which is less than $\alpha = .05$, demonstrating a significant association at the 5% level of significance as well.

The number of batsmen scoring more than 30 runs evidently impacts the team's chances of winning. As this number increases, the winning percentage also rises. When at least 2 players score more than 30 runs, the Bangladesh team tends to win 66.7% of the matches. This association is statistically significant at the 5% level, as indicated by the *p*-value of .025, which is less than $\alpha = .05$.

Similarly, the number of boundaries scored has a noticeable effect on the team's likelihood of winning. As the boundary count increases, the winning percentage (57.1%) surpasses that when the count is less than 20. This relationship is statistically significant at the 5% level, with a *p*-value of .031, which is less than $\alpha = .05$.

Binary logistic model

In this section, we have done our required analysis on the basis of Binary Logistic Regression. In Binary Logistic Regression analysis, we have selected the first category of response as the baseline category which is 'Lose'. Similarly, the first category of each of our categorical explanatory variables has been considered as the baseline category.

Location

We employed 'Home' as the reference category for the 'Location of the match' variable in our analysis. We then compared the odds ratios for the remaining two categories: 'Asia' and 'Other region.' According to the results presented in Table 4, the odds ratio for the 'Asia' category is 0.244. This implies that the odds of winning a match are approximately 0.244 times lower when the match is played in Asia (away from home) compared to matches played at home. In percentage terms, this suggests a 75.59% reduction in the likelihood of winning when the match is held in Asia as opposed to home.

Likewise, for the 'Other region' category, the odds ratio is 0.245, indicating that the odds of winning a match are approximately 0.245 times when the match is played in other regions compared to matches played at home. In percentage terms, this translates to a 75.47% decrease in the chance of winning when the match occurs in other regions rather than at home. The corresponding *p*-values for both categories are .015845 and .013582, respectively. These *p*-values fall below the conventional significance level of .05, signifying that the coefficients for both 'Asia' and 'Other region' are statistically significant at the 5% significance level. As a result, we have sufficient evidence to reject the null hypothesis and conclude that the location of the match significantly impacts the likelihood of winning the match.

Time

We've designated 'Day' as the baseline category for the 'Time' covariate in our analysis. As shown in Table 4, the odds ratio for 'The match is played at night' is 1.082. This odds ratio indicates that the likelihood of

winning the match at night is approximately 1.082 times that of winning during the day. Alternatively, we can express this as an 8.2% higher probability of winning the match when it's played at night compared to daytime. However, since the associated *p*-value exceeds the conventional significance threshold of 0.05, we lack sufficient evidence to deem the 'Time' coefficient statistically significant at the 5% significance level. Consequently, we cannot confidently assert that the timing of the match (day or night) significantly influences the odds of winning, based on our data analysis.

Shakib

We chose 'Absent' as the baseline category for the 'Shakib' variable in our analysis. According to the findings in Table 4, the odds ratio for 'Shakib being present in the match' stands at 1.1668. This odds ratio signifies that the likelihood of winning the match is approximately 1.1668 times higher when Shakib is present compared to when he is absent. In simpler terms, the presence of Shakib in the match is associated with a 16.68% greater chance of winning than when he is absent. However, the *p*-value linked with this odds ratio is .801, surpassing the customary significance threshold of .05. This result indicates that the 'Shakib' coefficient does not attain statistical significance at the 5% level. Consequently, we lack sufficient evidence to reject the null hypothesis, which suggests that Shakib's presence does not significantly impact the likelihood of winning the match.

Five pillars

We have designated 'absent' as the baseline category for the 'Five Pillars' covariate in our analysis. As per the findings presented in Table 4, the odds ratio for the 'Five Pillars' being 'present' stands at 0.867. This odds ratio implies that the odds of winning the match are approximately 0.867 times when the 'Five Pillars' are present compared to when they are absent. To put it differently, if the 'Five Pillars' are present, there is a 13.3% reduced chance of winning the match compared to when they are absent. However, the associated *p*-value for this odds ratio is .829, exceeding the customary significance threshold of .05. Consequently, the coefficient for 'Five Pillars' does not achieve statistical significance at the 5% level. Therefore, we lack sufficient evidence to reject the null hypothesis, which suggests that the presence of the 'Five Pillars' does not exert a statistically significant influence on the odds of winning the match, based on the data analysed.

Captain

We selected 'Mahmudullah' as the reference category for the 'Captain' variable in our analysis. We then compared the odds ratios for the three other categories: 'Mashrafe,' 'Shakib,' and 'Others.' According to the results presented in Table 4, the odds ratio for the 'Mashrafe' category is 0.976. This implies that the odds of winning a match are approximately 0.976 times when Mashrafe is the captain, in comparison to Mahmudullah being the captain. This translates to a 2.4% lower chance of winning the match when Mashrafe is the captain. Similarly, for the 'Shakib' category, the odds ratio is 1.368. This suggests that the odds of winning a match are approximately 1.368 times higher when Shakib is the captain compared to Mahmudullah being the captain, corresponding to a 36.8% greater chance of winning. Additionally, for the 'Others' category, the odds ratio is 1.93, indicating that the odds of winning a match are approximately 1.93 times when the captain is from another category compared to Mahmudullah being the captain. This results in a 93% higher chance of winning the match.

However, the associated *p*-values for 'Mashrafe,' 'Shakib,' and 'Others' are 0.97, 0.64, and 0.35, respectively. These *p*-values exceed the conventional significance level of .05, indicating that the coefficients for 'Mashrafe,' 'Shakib,' and 'Others' are not statistically significant at the 5% level. Therefore, we lack sufficient evidence to reject the null hypothesis, suggesting that the choice of captain from the 'Mashrafe,' 'Shakib,' or

'Others' categories does not exert a statistically significant impact on the likelihood of winning the match compared to Mahmudullah being the captain.

Bat first

We have designated 'NO' as the reference category for the 'Bat First' covariate in our analysis. According to the findings presented in Table 4, the odds ratio for 'Bat First' being 'YES' is 1.588. This odds ratio signifies that the odds of winning the match are approximately 1.588 times when the Bangladesh team opts to bat first compared to when they do not choose to bat first. Alternatively, we can express this as a 58.88% increased chance of winning the match when the Bangladesh team decides to bat first. However, the associated *p*-value for this odds ratio is .293, which surpasses the customary significance level of .05. Consequently, the coefficient for 'Bat First' does not achieve statistical significance at the 5% level. Therefore, we lack sufficient evidence to reject the null hypothesis, implying that the decision to bat first by the team does not have a statistically significant impact on the likelihood of winning the match, based on the data analysed.

Table 4. Coefficients, Standard Errors, Odds Ratios and p values of the Binary Logistic Regression.

Explanatory Variables	Coefficient (β)	Standard Error	Odds ratio (e^{β})	*p*-value
Intercept	0.506	0.778	1.659	.515
Location				
Asia	-1.41	0.585	0.244	.016
Other	-1.405	0.569	0.245	.014
Time				
Night	0.079	0.497	1.082	.874
Shakib				
Present	0.154	0.614	1.167	.802
Five Pillars				
Present	-0.143	0.663	0.867	.829
Captain				
Mashrafe	-0.024	0.735	0.976	.974
Shakib	0.313	0.676	1.368	.643
Other	0.657	0.702	1.93	.349
Bat First				
Yes	0.462	0.44	1.588	.293
Score				
>150	0.098	0.583	1.103	.867
One Digit score				
3 to 6 players	-1.133	0.495	0.322	.022
>6 players	-2.726	0.709	0.065	0
Most wicket				
At least 1 player has taken 3 or more wickets	3.168	1.304	23.749	.015
Thirty plus run				
At least 2 players scored 30+ runs	0.005	0.753	1.005	.995
Boundaries				
Boundaries scored more than 20	0.111	12(42.9%)	1.117	.869

Score: We have designated 'Less than 150' as the reference category for the 'Score' covariate in our analysis. We then compared the odds ratio for the 'More than 150' category. According to the findings presented in Table 4, the odds ratio for 'Score' being 'More than 150' is 1.103. This odds ratio suggests that the odds of winning the match are approximately 1.103 times when the team's score is 'More than 150' compared to when it is 'Less than 150.' In percentage terms, this translates to a 10.3% greater chance of winning the match when the team's score exceeds 150 compared to when it is below 150. However, the corresponding *p*-value for 'Score' being 'More than 150' is .867, exceeding the conventional significance level of .05. This result indicates that the coefficient for 'Score' is not statistically significant at the 5% level. Consequently, we lack sufficient evidence to reject the null hypothesis, suggesting that the difference in match outcomes based on the team's score is not statistically significant at the 5% level.

One-Digit Score: In our analysis, we explored the connection between the 'One-digit score' covariate and the likelihood of winning a cricket match. The 'One-digit score' variable encompasses three categories: 'Less than three players' (which we use as the reference category), 'Between three to six players,' and 'More than six players.' According to the findings presented in Table 4, for the 'Between three to six players' category, the odds ratio is 0.322. This indicates that when there are between three to six players who score one-digit runs, the chances of winning the cricket match are approximately 0.322 times compared to when there are fewer than three players scoring one-digit runs. In simpler terms, having between three to six players with one-digit scores is associated with a 67.8% reduced likelihood of winning the match compared to having less than three players with one-digit scores. Furthermore, the corresponding *p*-value for this odds ratio is .022, falling below the significance threshold of .05. This suggests that the coefficient for 'Between three to six players' is statistically significant, and we can confidently affirm that this category has a significant impact on the outcome of winning the cricket match.

For the 'More than six players' category, the odds ratio is 0.065. This implies that when there are more than six players with one-digit scores, the odds of winning the match are approximately 0.065 times compared to when there are fewer than three players with one-digit scores. In simpler terms, having more than six players with one-digit scores is associated with a substantial 93.5% reduction in the odds of winning the match compared to having less than three players with one-digit scores. Additionally, the corresponding *p*-value for this odds ratio is .0001, significantly below the significance level of .05. This indicates that the coefficient for 'More than six players' is highly statistically significant, and we can confidently assert that this category exerts a significant influence on the outcome of winning the cricket match.

Most wicket

We have defined the category of interest for the 'Most wicket' covariate as 'At least 1 player has taken 3 or more wickets,' while the reference category pertains to situations where no player has achieved this milestone in our analysis. According to the findings presented in Table 4, the odds ratio for 'At least 1 player has taken 3 or more wickets' is 23.749. This odds ratio signifies that when at least one player accomplishes this feat, the odds of winning the match increase by approximately 23.75 times compared to situations where no player has achieved it. In simpler terms, if the team manages to have at least one player take 3 or more wickets, there is a substantial and statistically significant improvement in the likelihood of winning the match.

Additionally, the *p*-value associated with this odds ratio is .015152, which falls below the conventional significance level of .05. This implies that the coefficient for 'At least 1 player has taken 3 or more wickets' is statistically significant at the 5% level. Consequently, we have robust evidence to reject the null hypothesis, firmly asserting that having at least one player who has taken 3 or more wickets significantly influences the team's chances of winning the match.

Thirty plus run

We have selected 'At least 2 players scored 30 plus runs' as the baseline category for the 'Thirty plus run' covariate in our analysis. We then compared the odds ratio for the alternative category, denoted as 'otherwise.' Based on the findings presented in Table 4, the odds ratio for 'otherwise' is 1.005. This odds ratio signifies that the odds of winning the match are approximately 1.005 times when there are fewer than 2 players who scored 30 plus runs (i.e., 'otherwise') in comparison to the scenario where at least 2 players scored 30 plus runs. In terms of percentages, this translates to a slight 0.5% increase in the likelihood of not winning the match when fewer than 2 players achieve this run milestone, as opposed to when at least 2 players score 30 plus runs. However, it's worth noting that the *p*-value exceeds the conventional significance level of .05, indicating that the coefficient for 'Thirty plus run' is not statistically significant at the 0.05% level.

Boundary

We have designated 'Boundaries scored less than 20' as the baseline category for our analysis. According to the data presented in Table 4, the odds ratio for 'Boundaries scored more than 20' in the match is 1.117. This implies that the odds of winning the match increase by a factor of 1.117 when there are 'Boundaries scored more than 20' in comparison to when 'Boundaries scored less than 20' are observed. Put differently, if the team manages to score 'Boundaries more than 20,' there is an 11.7% higher chance of winning the match compared to when they score 'Boundaries less than 20.'

However, the associated *p*-value of .869 indicates that the coefficient is not statistically significant at the 0.05% significance level. Consequently, we lack sufficient evidence to reject the null hypothesis, suggesting that 'Boundaries scored less than 20' does not have a significant impact on the likelihood of winning the match.

CONCLUSIONS

In our comprehensive research on Bangladesh national T20 cricket from 2006 to 2023, we uncovered key insights into the factors behind successful performances.

1. In the last decade, T20 cricket has surged in popularity, captivating audiences and players worldwide. While some cricket powerhouses like England, Pakistan, Australia, India, and South Africa have embraced the format, others, including Bangladesh, Afghanistan, Zimbabwe, and Sri Lanka, have faced challenges adapting to it.
2. Our research aimed to analyse factors affecting Bangladesh men's cricket team performance using ESPN Cricinfo data. We used binary logistic regression to study whether matches were won or lost.
3. Our findings were intriguing. Three key factors stood out among the variables examined: "*Location*" of the match, the performance of a player with "*Most Wickets*," and the frequency of "*One-Digit Scores*" all had significant impacts on the team's overall performance.
4. Surprisingly, expected factors like Shakib and the "*Five Pillars*" had no significant impact on the team's performance.
5. Our findings have profound implications, providing a strategic roadmap for the Bangladesh men's cricket team to improve their T20 performance and shape their cricketing future.

Practical applications

1. Match location significantly impacts Bangladesh Team's performance. Adapting strategies, pitch preparation, and team compositions for different locations can enhance their chances of winning away from home.

2. The strong correlation between wickets taken by bowlers and positive match outcomes underscores the importance of a potent bowling attack. Focusing on bowlers' skills, strategic variations, and match-specific combinations can consistently disrupt opponent strategies.
3. The correlation between runs scored by batsmen and positive match outcomes highlights the need for focused training in innovative stroke play and countering various bowling styles, ensuring consistent and impactful contributions from the batting unit.

Limitations

Our analysis mainly centred on specific factors like match location, match time, presence of Shakib, captaincy, batting, and bowling. We didn't delve into other potentially influential variables such as weather, player form, injuries, fielding, team morale, captaincy decisions, and opposition strength, which could provide a more comprehensive understanding of performance dynamics. Limited available research and data constraints led to the exclusion of various performance variables from our study.

AUTHOR CONTRIBUTIONS

Conceptualization: Anamul Haque Sajib. Supervision: Anamul Haque Sajib. Methodology: Anamul Haque Sajib, Shakib Hasan Limon, Adiat Ibn Naser. Data curation: Shakib Hasan Limon, Adiat Ibn Naser. Writing—original draft preparation: Anamul Haque Sajib, Shakib Hasan Limon, Adiat Ibn Naser, Goutam Saha. Writing—review and editing: Anamul Haque Sajib, Shakib Hasan Limon, Adiat Ibn Naser, Goutam Saha. All authors have read and agreed to the published version of the manuscript.

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ORIGINAL ARTICLE

Match-play, training workloads and sensorimotor and neuromuscular performance of elite young soccer players

Colin Clancy . *School of Health Sciences. Queen Margaret University. Edinburgh, United Kingdom. Football Science and Medicine Department. Hibernian Football Club. Edinburgh, United Kingdom.*
Nigel Gleeson. *School of Health Sciences. Queen Margaret University. Edinburgh, United Kingdom.*
Tom Mercer. *School of Health Sciences. Queen Margaret University. Edinburgh, United Kingdom.*

ABSTRACT

Purpose: The purpose of this study was to assess sensorimotor and neuromuscular performance capabilities over an in-season microcycle in early-career professional soccer players and to examine the relationship with training and match-play workload. Methods: Sensorimotor and neuromuscular performance capabilities (isometric knee extensor: force replication error, peak force, electromechanical delay, rate of force development) of 12 professional soccer players were assessed over a 7-day period. Training and match-play workload was also recorded over the same period for each player (high-intensity running distance). Fluctuations in sensorimotor and neuromuscular performance and workload variables were analysed. Results: There was evidence of fluctuations in sensorimotor and neuromuscular performance capability over the microcycle that reached statistical (p < .005) and practical (18.1% [baseline-to-peak]) significance alongside heterogeneity in training and match workload (264% [coefficient of variation], p < .0005). Some temporal congruence among fluctuating patterns of intra-microcycle training and match-play load and concomitant electromechanical delay performance was noted (p < .005). Asynchronous responses were observed for peak force, but rate of force development and force replication error capabilities were unchanged during the microcycle. Conclusion: While some neuromuscular performance capabilities fluctuate over an in-season microcycle and are influenced partially by high-intensity running workload, sensorimotor performance capabilities were unchanged during the microcycle.

Keywords: Performance analysis, Force error, Muscle activation, Strength, Training workload, Match-play workload.

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Corresponding author. *Hibernian Training Centre, East Mains, Tranent, EH35 5NG. Edinburgh, United Kingdom.*
E-mail: cclancy@hibernianfc.co.uk
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INTRODUCTION

Effective sensorimotor (SM) performance is regulated in part by neuromuscular (NM) performance capabilities involving static (ligaments, joint capsule, cartilage) and dynamic (feedback and feedforward control over skeletal muscle) componentry (Riemann and Lephart, 2002a). Mechanistic interactions between NM fatigue and compromised SM performance have been implicated in compromised capability within the latter stages of both halves during match-play (Ekstrand et al., 2011). This expectation is corroborated indirectly by laboratory-induced fatigue detrimentally affecting proprioceptive acuity in high-level soccer players during an ankle joint repositioning task (Mohammadi and Roozdar, 2010) and by match-play decreasing postural stability in elite young soccer players (Brito et al., 2010). Similarly, research shows coincidence amongst reduced force-matching acuity, exercise-induced muscle damage (Proske et al., 2004) and reduced NM performance following eccentric exercise in healthy non-athletic populations (Twist et al., 2008). In contrast, a routine training session in elite youth soccer players failed to induce fatigue-related impairments to postural control (Gioftsidou et al., 2011), while a 90-minute treadmill protocol, designed to replicate the physical demands of match-play, failed to alter single leg stability performance (Greig and Walker Johnson, 2007). Thus the literature has only partially illuminated the extent to which evidence of compromised SM and NM performance from simulations and restricted episodes of soccer match-play might calibrate directly to what could be expected within the wider environment of professional soccer. For example, while match-play appears to provoke substantive strength impairment for up to 72 hours (Cohen's *d*, 0.7) (Silva et al., 2018; Rampinini et al., 2011), temporally-congruent data for SM performance remains elusive.

The in-season period in professional soccer comprises a series of competitive microcycles incorporating training, match-play and the post-match recovery epoch (Owen et al., 2013). Within each microcycle, periodisation strategies maximise stress and recovery, with the goal of maintaining peak performance leading into competition (Martin-Garcia et al., 2018). The primary aim of this study was to characterise SM and NM performance capabilities over an in-season, competitive microcycle in elite young soccer players. This was accomplished by using an array of relevant metrics and documenting the concomitant training load, through the lead-up to match-play, the event itself and during the recuperative epoch. Given the potential for elevated workloads involving high-intensity running to provoke a reduced neuromuscular capacity (Goodall et al., 2017; Griffin et al., 2010; Cormack et al., 2008) a secondary aim was to explore the extent of congruence amongst fluctuating patterns of intra-microcycle training and match loads, SM performance and NM responses. It was hypothesised that there would be correspondence amongst oscillations of intra-microcycle training workload and SM and NM performances, with a nadir in performance at the end of match-play. In so doing, we hoped to inform practitioners about the potential vulnerability of elite players to diminished NM and SM performance.

METHODS

Participants

Twelve early career professional soccer players (age: 19.2 ± 1.1 years; height: 183.3 ± 6.1 cm; body mass: 76.1 ± 7.8 kg) (defenders = 4, midfielders = 4, forwards = 4), from the development squad (DEV) of a Scottish Premiership football club gave written informed consent to participate in the study. The physical profile of the squad is detailed in Table 1.

Design

To assess patterns of SM and NM performance over an in-season microcycle, data were collected from each of 12 players over a single training microcycle within the same phase of the competitive season (mid-season).

To ensure data was collected within a standardised time frame (within 15 minutes of the cessation of the relevant training or match-play session), this data was accumulated over a series of three separate microcycles, with each microcycle incorporating a match against a different professional team and involving a random selection of four players completing all assessments. The microcycle comprised of standardised training sessions and a match (Table 2a) for each participant. Training volumes were comparable across the three microcycles (Table 2b). Assessments were undertaken at baseline on the day prior to the match (MD-1), on the match-day [immediately post-match] (MDpost) and on the second (MD+2) and third (MD+3) days after the match. Excepting MDpost, assessments occurred at the same time each morning (± 1 hour) mitigating circadian variation and always prior to any physical exertion. All twelve players completed a minimum of 60 minutes of match-play in their designated match and participated in all training sessions within the microcycle. Prior to the study, ethical approval was granted by the institutional ethics committee (Queen Margaret University, Research Ethics Panel, Governance and Quality Enhancement) and conformed fully to the declaration of Helsinki.

Table 1. Mean (± SD) of physical performance profiling results from in-season assessment point.

Physical Capacity	Test	Mean (± SD)	Descriptive Rating*
Aerobic	Yo-Yo IE1	2576 (± 278) m	Moderately High
Speed	20 m Sprint	2.88 (± 0.09) s	Normal
Strength	Relative Back Squat 4RM	105 (± 15) % body mass	Moderately High

*Note. *Based on unpublished comparisons from 5 seasons of profiling similar cohorts.*

Table 2a. Microcycle schedule.

Day	Day Relative to Match-day (MD)	Training Session 1 Description	Training Session 2 Description	Experimental Assessment Timing
Monday	MD-1	Football session	N/A	Pre-training
Tuesday	MD	Match-play	N/A	Post-match
Wednesday	MD+1	Rest day	N/A	N/A
Thursday	MD+2	Football session	Full body strength	Pre-training
Friday	MD+3	Football session	Lower limb power	Pre-training

Table 2b. Daily high intensity running workload during microcycle trials.

Day Relative to Match-day (MD)	Microcycle 1	Microcycle 2	Microcycle 3
MD-1	203 m	241 m	140 m
MD	623 m	737 m	769 m
MD+2	149 m	121 m	88 m
MD+3	49 m	92 m	20 m

Procedures

All sensorimotor and neuromuscular assessments were carried out on a custom-built dynamometer, incorporating a load cell (range: 3 kN; Tedea-Huntleigh, Cardiff, UK; technical error, recorded: ± 0.95 N, 95% confidence limits, as described previously (Clancy et al., 2021).

The volitional neuromuscular assessment consisted of 3 maximum isometric knee extension trials (30° knee flexion) from which peak force (PF), rate of force development (RFD) and electromechanical delay (EMD) were derived. All assessments involved the participants' dominant leg, as determined by their preferred kicking leg. RFD was calculated as the average rate of force increase between 25% and 75% of PF.

Concomitant electromyographic activity (EMG) was recorded from the m. vastus lateralis during the estimation of PF as described previously, using bipolar surface electrodes that were parallel to the orientation of the muscle fibres. EMD was defined as the time delay between the onset of electrical activity and the onset of force. The latter were defined as the first points in time where the recording signals for the EMG and load cell systems consistently exceeded the 95% confidence limits of background electrical noise amplitude, respectively (Minshull et al., 2009).

After a standardised warm-up, consisting of progressive sub-maximal efforts (perceived 50 %, 75 %, 95 % of PF), and then muscular relaxation, participants were instructed to rapidly and forcefully extend the knee against the immovable lever arm of the dynamometer (~3 s), which was repeated twice more (30 s rest-recovery).

Sensorimotor performance was defined as the bias or constant force error (FE) when matching a 'blind' target force, specified as 50 % of a player's daily peak force to simulate on-field peak power (Zatsiorsky and Kraemer, 2006), with lower scores reflecting better SM performance (Peer and Gleeson, 2018). Each participant was acquainted with his concealed target force during two familiarisation trials that preceded testing (Gleeson et al., 2013). No feedback regarding performance was given to the participants during the test. The best response of two trials was used for subsequent analysis. The equation used to compute force error (FE) is outlined in Equation 1.

Equation 1. Force Error.

$$FE = \left[\frac{(observed\ performance\ score - target\ performance\ score)}{target\ performance\ score}\right] \times\ 100\ \%$$

Quantification of Training/Match Workload

Training workload (WL) was calculated for every field training session and match played over the 6-week period using a GPS (Catapult Sports, Melbourne, Australia) sampling at a frequency of 10 Hz.

Post-session, data were downloaded using the manufacturer's software and then exported and stored on a custom-built spreadsheet. The metric used to monitor player match-play and training WL over the microcycle was total high intensity running distance (all running over 19.5 $km \cdot h^{-1}$).

Single-measurement reproducibility associated with the NM and SM performance indices PF, RFD, EMD and FE for the knee extensors of participants was 5.5%, 26.3%, 6.7% and 12.3%, respectively (coefficient of variation). For each measure of SM and NM performance, the participant's mean trial response of three was used.

Statistical analysis

Group means ± standard deviations (SD) described outcome scores. Pearson's product-moment correlation coefficients (*r*) were used at baseline to assess any dependency amongst indices assessing SM and NM performance (PF, RFD, EMD and FE).

Separate single-factor (time [MD-1: MDpost; MD+2; MD+3]) analyses of variance (ANOVAs), with repeated measures, tested hypotheses relating to PF, RFD, EMD, and FE (SPSS Vn. 23, IBM SPSS Illinois, USA). Intra-microcycle changes in match-play and training WL were analysed similarly. *A priori* planned reverse Helmert orthogonal difference testing located anticipated time-specific effects. Assumptions underpinning the

use of ANOVA parametrically were checked and any violations countered using data transformation (log_{10}) and Greenhouse-Geisser ($_{GG}$) adjustments. Statistical significance was accepted at $p < .05$.

Congruence amongst fluctuating patterns of intra-microcycle match-play and training WL and SM (FE) and NM performance responses (PF; RFD; EMD) was examined using players standardised (z-score) data and separate univariate factorial (mode [WL; SM performance response; NM performance response]*time [MD-1: MDpost; MD+2; MD+3]) ANOVAs, with repeated measures on both factors. Temporal correspondence amongst dose-response patterns was indicated by an absence of factorial interaction. *A priori* planned reverse Helmert orthogonal difference and polynomial trend analyses characterised the expected intra-microcycle oscillatory patterns of fluctuation in players' match-play and training WL and concomitant adaptation of SM and NM performance.

A priori experimental design sensitivity estimation offered an approximate statistical power of 0.8 for avoiding intrusion of type-II errors for a medium relative size of change (Cohen's *d*, 0.5) in the study's primary outcome, FE, at the study's end-point (MDpost), requiring an approximate cohort' sample size of n = 8 (www.sportsci.org).

RESULTS

Group mean (± SD) intra-microcycle scores for NM and SM outcomes of PF, RFD, EMD and FE are shown in Figures 1(a), 1(b), 1(c) and 1(d), respectively. At baseline (MD-1), there were modest relationships amongst indices of SM and NM performance (FE with PF; *r*, - 0.60; $p < .05$; PF with RFD; *r*, 0.62; $p < .05$), suggesting that each offered an independent perspective on players' intra-microcycle performance capabilities.

There was a trend towards an overall significant difference in intra-microcycle PF performance capability characterised by a decline and subsequent restoration of performance ($F_{(3,33)} = 2.7$; $p = .06$). However, planned *a priori* hypothesis testing showed that the reduction between MD-1 and MDpost contributed most to the overall variation over time ($F_{(1,11)} = 12.1$; $p < .005$) (Figure 1(a)). The evidence for intra-microcycle fluctuations in PF performance was emphasised by analysis of z-scores in which variance in PF amongst participants was controlled statistically ($F_{(3,33)} = 3.1$; $p < .05$), with *a priori* planned comparisons showing depressed performance capability on MDpost relative to MD-1 ($F_{(1,11)} = 9.1$; $p < .01$). Relative to baseline (MD-1), impairment in absolute PF was substantive (ES: 0.32 [MDpost] and 0.40 [MD+2]).

By contrast, analysis of RFD absolute performance scores suggested that force-time dependent NM capability remained unchanged (2460 ± 1280 $N \cdot s^{-1}$; *ns*) during the intra-microcycle period (Figure 1(b)).

Intra-microcycle EMD performance capability was characterised by a decline (18.1% reduction compared to baseline [33.2 ± 5.8 ms]) and subsequent restoration of performance ($F_{(3,24)} = 10.8$; $p < .0005$) (Figure 1(c)). Planned *a priori* hypothesis testing showed that relative to baseline (MD-1), a substantial impairment in EMD at MDpost (ES: 1.1; ($F_{(1,8)} = 9.5$; $p < .05$), followed by recovery at MD+2 ($F_{(1,8)} = 17.4$; $p < .001$) and MD+3 ($F_{(1,8)} = 10.1$; $p < .01$), which either matched or modestly surpassed baseline levels (ES: 0.9 and 1.9, respectively), contributed most to the overall significant changes in EMD.

Force error remained constant across the microcycle (13.3 ± 10.5 %; *ns*) implying that SM performance capability was preserved over the microcycle duration (Figure 1(d)).

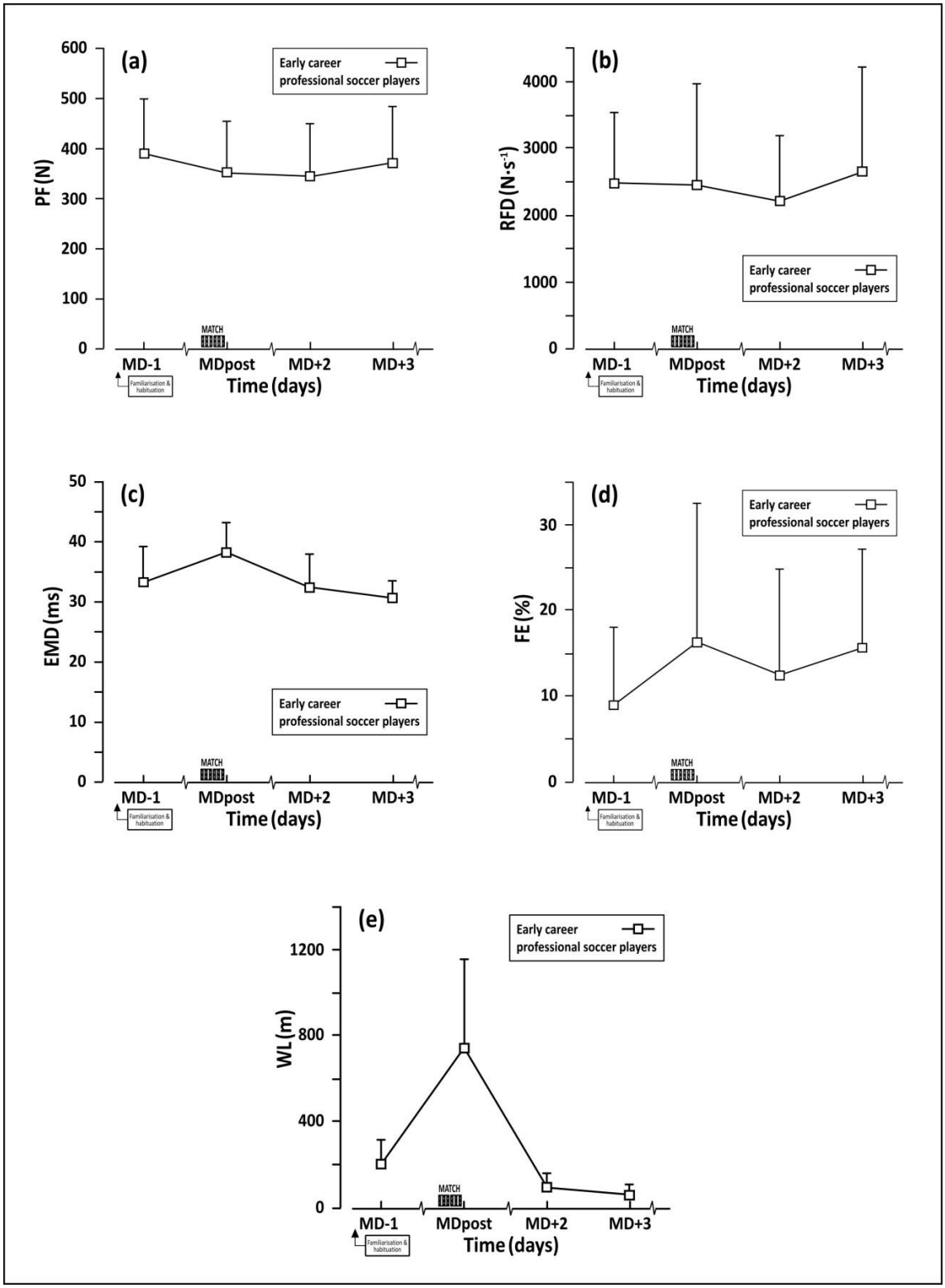

Figure 1. Group mean (± SD) intra-microcycle scores for NM and SM outcomes of PF (a), RFD (b), EMD (c) and FE (d) associated with the knee extensors of early career professional soccer players, with concomitant match-play and training WL (e) (high intensity running distance, over 19.5 km·h-1) recorded at assessment times MD-1, MDpost, MD+2 and MD+3.

Significant fluctuations amongst match-play and training WL were observed within the microcycle ($F_{(1.1,12.1)}$ = 31.0; p < .005), with planned *a priori* hypothesis testing showing that the greatest player exposure to high intensity running occurred on match-day (264 % greater than baseline [MD-1]; ES: 1.8) ($F_{(1,11)}$ = 27.8; p < .0005) (Figure 1(e)).

Players' standardised (z-score) data was used to explore for congruence amongst fluctuating patterns of intra-microcycle match-play and training WL and concomitant SM and NM performance responses. Factorial interaction for WL with PF showed that patterns of intra-microcycle fluctuation amongst the amount of high intensity running during match-play and training and strength-related NM performance were incongruent over time ($F_{(3,33)}$ = 19.0; p < .0005; Figure 2). *A priori* planned reverse Helmert difference analyses showed that the interaction associated with the period of increased match-play WL compared to baseline (MD-1) and correspondingly depressed strength capability ($F_{(1,11)}$ = 55.2; p < .0005), together with diminished WL towards the end of the microcycle and concomitant restoration of strength performance ($F_{(1,11)}$ = 12.6; p < .01), contributed most to the interactive incongruence between WL and this index of NM performance.

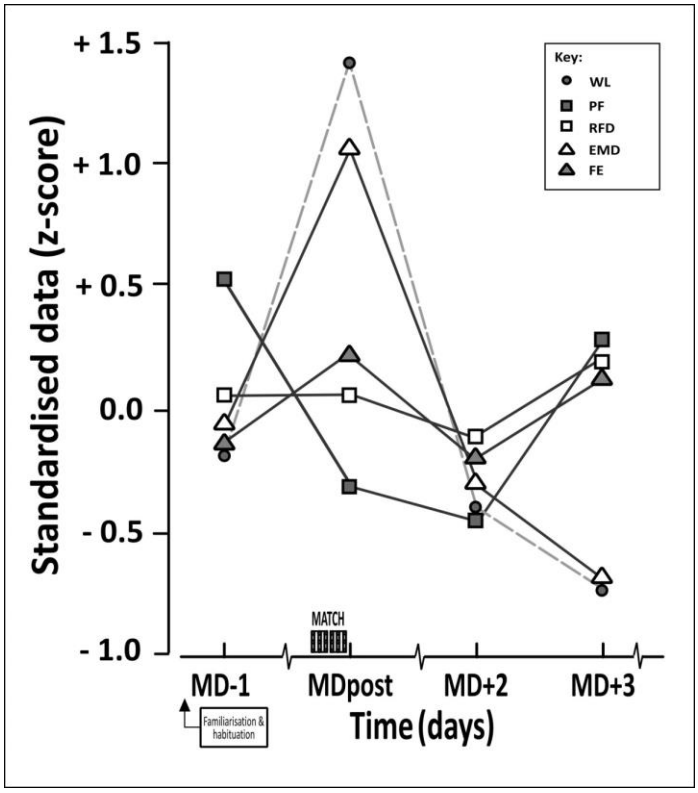

Figure 2. Group mean intra-microcycle standardised scores for indices of match-play and training WL (*closed circle*) and corresponding indices of SM (FE [*filled triangle*]) and NM performance (PF [*filled square*]; RFD [*open square*]; EMD [*open triangle*]) of the knee extensors of early career professional soccer players recorded at assessment times MD-1, MDpost, MD+2 and MD+3.

Similarly, temporal incongruence was noted over time for WL with the force-time dependent index of RFD ($F_{(3,33)}$ = 9.3; p < .0005; Figure 2). Planned difference analyses characterising RFD responses, which had remained constant over the microcycle, and concomitant initial ($F_{(1,11)}$ = 24.4; p < .0005) and end ($F_{(1,11)}$ =

7.7; $p < .05$) fluctuating patterns in players' WL underscored intra-microcycle asynchrony between RFD and WL metrics.
Incongruence was also noted for WL and the SM index of FE ($F_{(3,33)} = 8.3$; $p < .0005$), with correspondingly influential and divergent patterns at the start ($F_{(1,11)} = 9.0$; $p < .05$) and end ($F_{(1,11)} = 10.6$; $p < .01$) of the microcycle.

EMD showed a non-significant (*ns*) factorial interaction in its response to WL over time, and thus a convergent but inverse pattern of WL and neuromuscular response, given that higher EMD scores reference increasing muscle activation latencies. *A priori* planned polynomial trend analyses primarily characterised the intra-microcycle oscillatory patterns in players' match-day and training WL and concomitant EMD as cubic curvilinear responses ($F_{(1,8)} = 113.9$; $p < .0005$).

DISCUSSION

The main finding of this study was that sensorimotor performance appeared to be unaffected within an in-season training microcycle. In contrast, whether expressed in absolute or standardised units, PF performance in the knee extensors was diminished substantially immediately following match-play (MDpost; ES: 0.34) and at MD+2 (ES: 0.40) compared to baseline (MD-1). The latter reduction, which corresponds to an 11.1% loss in strength is consistent with previous evidence in the same musculature following exposure to acute match-play (15%) (Goodall et al., 2017). Elevated levels of high-intensity running during match-play involving high eccentric demands of soccer actions have been hypothesised to cause damage and inhibited performance to portions of the lower limb musculature (Hortobágyi et al., 1998). A restoration of baseline levels of PF performance at MD+3 (trivial ES: - 0.17) was consistent with previous research describing restoration of NM performance at 72 hours post-match play (Nédélec et al., 2012) and supports the current recommendations to reduce the volume and intensity of training for 48 hours post-match (Martin-Garcia et al., 2018).

Impaired EMD performance (18.1%) immediately following match-play suggests that game-related exercise stress disrupted post-synaptic processes such as the transmission of force through the series elastic component and alterations within the excitation-contraction coupling process (Howatson, 2010). Comparable research evidence in elite male soccer players is lacking, but arduous soccer-activities increased EMD latencies by 58.4% (De Ste Croix et al., 2015) in female players, who have previously demonstrated prolonged EMD latencies (Blackburn et al., 2009; Granata et al., 2002; Zhou et al., 1995).

High-intensity athletic performance requires the rapid uptake of slack within the musculotendinous unit to facilitate rapid force expression (Van Hooren and Bosch, 2016). Sub-optimal EMD within soccer match-play or training has the potential to negatively impact physical performance capability or render soccer players vulnerable to ligamentous injury (Gleeson et al., 1998a), given that a limited time-frame exists in which to overcome potentially harmful dynamic forces. A more rapid restoration of capabilities to baseline levels of performance for EMD compared to PF may reference speculatively the former's greater relative biological importance to functionality in sports.

In a similar way, RFD remaining unaffected during the microcycle may indicate independence for this metric amongst recovery dynamics or mechanisms of fatigue-related resistance, whereby preservation of force-time related aspects of NM performance have been prioritised. A corollary may involve antecedent training influences having depressed RFD performance at the microcycle's commencement, with moderated responses subsequently. Indeed, this study's finding may conflict with that involving diminished RFD performance following exercise-induced muscle damage (Howatson, 2010).

Given that selected NM capabilities diminished over the course of the microcycle, the absence of a concurrent reduction in SM performance appears paradoxical. Components of the SM system contributing to the knee extensors' muscular efferent activation and force capacity showed diminished performance and a potential for compromised functional capacity, including for example, inflated joint vulnerability to injury. Nevertheless, concomitant intra-microcycle preservation of FE may imply that the knee joint's afferent sensory apparatus compensated for the negative impact of the physiological stresses within match-play and training.

Expectations for impaired SM performance within the microcycle derive from conflicting evidence of disruption (Brito et al., 2012) and maintenance (Gioftsidou et al., 2011) of performance and accumulating non-football-related research in which high intensity eccentric exercise elicited disruption of proprioception and precision of movement control (Proske et al., 2004; Twist et al., 2008). Speculatively, any match-play and training-related threats to musculoskeletal stability might provoke relative homeostasis in SM performance as a mechanism of innate biological protection.

Evidence for intra-microcycle heterogeneity in WL was demonstrated statistically for high intensity running distances and centred around a more than 2-fold greater volume during match-play compared to that within episodes of lead-in or recovery training. This finding is reflective generally of microcycle periodisation in which physical stress within the training content is managed to optimise stress, adaptation and recovery leading in to match-play (Owen et al., 2017). Intra-microcycle high intensity running distances showed large variation amongst players (as demonstrated by a within-group coefficient of variation (± 61.8%). Although this is surprising given that the players largely participated in the same sessions and match-play, it is likely to be at least partially reflective of the different positional demands and suggests that further exploration of an individualised or positional approach to WL tracking is justified. This finding is consistent with recent research showing peak demands (high speed running intensity) within training and competition varying by as much as 50% between centre-backs and wide-attackers (Abbott et al., 2018).

Players' intra-microcycle standardised scores, which moderated inter-player heterogeneity, facilitated direct comparisons amongst outcomes, including WL, and explored their temporal congruence. The complex oscillatory NM performance that had been noted for PF during the microcycle ($p < .0005$) was temporally incongruent with patterns observed for WL ($p < .005$; Figure 2). Thus, PF responses, as the net outcome amongst antecedent acute and chronic training loads, muscular damage, physiological restoration dynamics and adaptation mechanics, appeared to be independent of WL during the microcycle. Similarly, intra-microcycle responses of FE and RFD to WL fluctuations were also temporally incongruent, but FE and RFD performances had remained at a constant level, indicating limited possibilities for synchrony amongst shared mechanistic influences. In contrast, EMD had shown congruent temporal responses with intra-microcycle WL (Figure 2), and this synchrony, together with similar patterns of standardised effect, may reference an important mechanistic linkage, albeit inversely mirrored, in which peak WL levels that are associated with match-play, coincide with a nadir in EMD latencies. While NM performance's sensitivity to fluctuations in high intensity training and match workload has been noted previously (Cormack et al., 2008), the current study offers novel data linking high intensity running workload with EMD.

The extent of physiological disruption to homeostasis imposed by acute bouts of training stress, even when moderated by effective designs within periodisation, alongside match-play, is highly likely to be influenced by antecedent fitness capacity, which in turn, is influenced by prior chronic workload and genetic predisposition. It is worth noting that due to the timing of the study (mid-season), a period of acquisition of high levels of fitness had already occurred, with participants well prepared for the demands of high loads within training

and competition. Indeed, previous research has outlined the mediating influence of fitness on enhanced recovery (Johnston et al., 2015) and the athletic profile of the current participants (Table 1) may support this notion.

Overall, the significant temporal congruence shown amongst complex intra-microcycle oscillatory patterns for WL with EMD, but not for PF, together with preserved performance capabilities for RFD and FE, suggest that heterogeneous acute WLs have the potential to diminish some NM capabilities. The findings, which largely conflict with the study's prior expectations for congruence amongst SM and NM indices with WL, may have implications for optimising intra-microcycle periodisation strategies. Specifically, given the finding of diminished EMD capability following match-play, highlighting reduced functional stability of the knee joint, a shift in training focus during this recovery epoch from physical conditioning to recovery or technical drills, is recommended.

A limitation of the present study is the small sample size (n=12), although this is common in studies of players at a professional level. As alluded to earlier, it could be argued that a single joint force-matching trial is too simplistic to comprehensively capture complexities within soccer-related SM performance. While this approach to assessment mimics a clinical gold standard from which causal links between SM performance and musculoskeletal injury has been established, future research might usefully encompass an array of dynamic and more ecologically-valid SM assessments. Such an approach would offer adjunct information about the extent to which complex oscillatory patterns of intra-microcycle training loads might elicit SM responses as they approach physiological limits. Finally, although the use of statistical constructs such as analysis of participants' intra-microcycle z-scores was used to mitigate the effects of inter-individual variation, tactical and positional demands inevitably lead to heterogeneity in locomotor outputs during training and match-play which may in turn, elicit varied impact on NM and SM performance among players.

Practical applications

The findings of this study highlight a preservation of intra-microcycle SM performance, but reduced capacity to initiate force rapidly via increased EMD latencies. The latter may negatively impact performance and prophylactic function in the latter stages of match-play and during periods of high fixture concentration. Performance support practitioners should target muscular activation proximal to full joint extension (c. 30º of flexion) and concomitant dynamic stiffness within conditioning strategies to mitigate the effects of in-game WL, while also encouraging favourable strength adaptations and recovery.

CONCLUSION

This study explored the extent and congruence amongst fluctuating patterns of intra-microcycle WL with NM and SM performance responses. Heterogeneous training and match-play WL appears to drive fluctuations in NM performance only partially, with EMD performance compromised most during match-play. A statistical and practically significant decrease in performance was observed for PF, but RFD and SM performance capabilities were unchanged during the microcycle.

AUTHOR CONTRIBUTIONS

Colin Clancy: Research design, data collection, lead author. Nigel Gleeson: Research design, data collection, project supervisor. Tom Mercer: Research design, project supervisor.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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SCIENTIFIC JOURNAL OF SPORT AND PERFORMANCE

REVIEW ARTICLE

The sport tourism and regional economic development: A systematic review

Giovanni Raso . *San Antonio Catholic University of Murcia. Murcia, Spain.*
Domenico Cherubini. *San Antonio Catholic University of Murcia. Murcia, Spain.*

ABSTRACT

The main aim of this systematic review is to analyse the most recent literature regarding the relationship between sports tourism and its economic impact on a specific region. This research employed a systematic literature review methodology following PRISMA guidelines. A total of 64 relevant articles were identified through comprehensive searches across databases, resulting in the selection of 14 articles that met the established inclusion criteria for the study. The studies were analysed and synthesized to identify the key economic benefits and challenges of hosting sporting events. The review identified that sports tourism positively impacts regions by attracting tourists, creating job opportunities, and generating revenue for local businesses. Both small-scale and major sports events can potentially contribute to regional economic development. However, proper planning and management are essential to ensure that the benefits are maximized and that any negative impacts are minimized. There is need for further research to identify best practices for maximizing the economic benefits of sport tourism and to explore its potential for sustainable economic development.

Keywords: Sport tourism, Economic impact, Regional development, Small-scale sports events, Major sports events, Revenue generation, Sustainability, Planning, Management.

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Corresponding author. *San Antonio Catholic University of Murcia. Murcia, Spain.*
E-mail: graso@alu.ucam.edu
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INTRODUCTION

In recent years, sports tourism has attracted significant attention from researchers due to its status as one of the fastest-growing sectors in the tourism industry. An increasing number of tourists are venturing to new destinations to observe and engage in sporting events or activities. As the phenomenon of sports tourism has grown enormously in contemporary times, it has necessitated the need to analyse and evaluate its economic value and understand the community's perception regarding its socio-economic impact. Therefore, this article deepens the understanding of sports tourism and its economic influence on a host region by examining the most relevant research conducted on the topic.

According to Rómulo Jacobo et al. (2022), sports tourism is a type of travel that involves individuals or groups temporarily leaving their place of residence to engage in, observe, or participate in sports-related activities or events. It encompasses a wide range of activities, including attending major sporting events, participating in recreational sports, or visiting destinations associated with sports. As per Hinch & Higham (2001), sports tourism can significantly impact local economies, with the potential to generate revenue for businesses such as hotels, restaurants, and transportation companies. Moreover, they emphasize on the importance gaining a deeper understanding of residents' perspectives as these insights into residents' perceptions can be invaluable in shaping tourism policies and strategies. This information can help gain residents' support for sport tourism and support its sustainable growth.

A number of researchers explore two main types of sport tourism: active sport tourism and event sport tourism. Cheung et al. (2016) differentiate the two as; active sports tourism involves travelling outside one's usual environment to participate in sports activities, whereas event sports tourism involves travelling away from home to attend and spectate sporting events. Several studies (Romolo Jacobo et al., 2022; Tomino et al., 2020; Perić, 2018; Cheung et al., 2016) have suggested that in contrast to mega sports events, small-scale events yield more significant positive impacts on the host community. Indeed, the smallest events generally utilize pre-existing infrastructure, require fewer investments from the government, and generate more controllable crowds and traffic.

The main aim of this systematic review is to analyse the most recent literature regarding the relationship between sports tourism and its economic impact on a specific region. This study takes a big dive into the information presented by scholarly analysts including Hinch and Higham (2021), Tomino et al. (2020), Romolo Jacobo et al. (2022), Perić (2018) among others. These scholars have consistently directed their focus towards the intersection of sports tourism and regional economic development, contributing valuable perspectives that hold significance in this field. Given its rapid growth and increasing popularity, it is imperative to address the potential challenges and concerns related to the thriving sports tourism sector.

Amidst the rapid growth of sports tourism and its acknowledged potential for generating economic and community advantages, a critical knowledge gap exists concerning the relationship between sports tourism and regional economies. Thorough research is essential to address the following inquiries: What is the true impact of sports tourism on the economic landscape of host regions? What is the residents' perception of the economic impact of sport tourism? And what economic benefits come from hosting small-scale events as well as major sporting events?

The urgency for comprehensive research becomes evident when considering the pressing questions that remain unanswered. Firstly, determining the true impact of sports tourism on the economic landscape of host regions is crucial, as it holds the key to understanding the extent of its contribution to regional development

and sustainability. Secondly, delving into residents' perceptions of the economic impact of sports tourism provides valuable insights into the social dimension of this phenomenon, shedding light on the community's views and concerns. Lastly, the study of economic benefits arising from hosting both small-scale and major sporting events is pivotal, as it aids in assessing the cost-benefit analysis of such endeavours and informs future decision-making processes. This research endeavour is not only timely but also essential for policymakers, businesses, and communities to maximize the positive aspects of sports tourism while addressing potential challenges.

Aim of study

To comprehensively examine the relationship between sport tourism and economic effects on a host region, the phenomenon was analysed based on four different aspects listed below;

1. Explore the perceptions of local residents regarding the economic impact of sports tourism on their region.
2. Investigate the economic impact of small-scale sports events on the host region, considering factors such as infrastructure utilization and government investments.
3. Assess the economic impact of large-scale or mega-sport events on the host region, taking into account the scale, investments, and crowd management.
4. Examine the actual tourism influx numbers during the FIFA World Cup 2010 and identify the factors contributing to deviations from expected values, offering insights into event-specific challenges and opportunities.

METHODOLOGY

The methodology for this literature review was designed following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). A comprehensive search was conducted across various reputable databases, including Google Scholar, SCOPUS, and ProQuest. These databases were selected for their extensive coverage of academic literature across multiple disciplines, ensuring the retrieval of relevant studies regarding the objective of this review.

To identify pertinent literature, a systematic search strategy was employed using the following keywords: "*sports tourism*," "*sports events*," "*economic impact*," "*small-scale events*," and "*major sports events*." Boolean operators "OR" and "*AND*" were used to refine the search. The search terms were selected to capture a broad range of articles related to sports tourism and its economic effects on regions. The inclusion criteria were established to determine the eligibility of articles for this review and are indicated below;

- Articles published in English.
- Peer-reviewed studies.
- Publication date between 2000 and 2023.
- Articles containing information related to the economic impact of sports tourism or sports events on specific regions.

Upon implementing the search strategy, the initial results provided 126 articles. After eliminating 66 duplicate references, a total of 60 unique articles remained. Subsequently, a manual search was performed by scrutinizing the references of selected articles, and the Cited Reference tool was used to identify studies citing the initially retrieved articles. This supplementary search yielded an additional 4 articles. The combined results, comprising 64 articles, formed the basis for the review.

Each article's title was meticulously assessed to determine its potential relevance to the literature review. Titles deemed relevant were further examined by reviewing their abstracts to ascertain their suitability for inclusion in this study. Following the rigorous screening process, a total of 16 articles were initially identified as meeting the inclusion criteria. However, upon a comprehensive review of these articles, two were excluded as they primarily focused on the behaviour of sports tourists rather than the impact on the host region. Consequently, 14 articles were selected as they aligned with the established inclusion criteria and were deemed suitable for the study. The reasons for the exclusion of articles were based on consideration of the following aspects:

Certain publication types, such as conference abstracts, book reviews, editorials, and commentaries, were excluded to prioritize peer-reviewed research articles, ensuring a higher level of academic rigor.

- To capture the most recent developments and trends in the field of sport tourism, older publications falling outside the specified date range (2000-2023) were excluded.
- Duplicate articles were systematically removed to prevent redundancy and maintain a concise and clear representation of the selected literature.
- Articles not published in English were excluded to facilitate a comprehensive understanding of the selected literature.
- Articles from sources lacking academic credibility were excluded to ensure the reliability of the selected literature.
- Articles that did not directly address the core themes of the study, particularly the economic impact of sports tourism on host regions, were excluded to maintain focus and relevance to the research objectives.

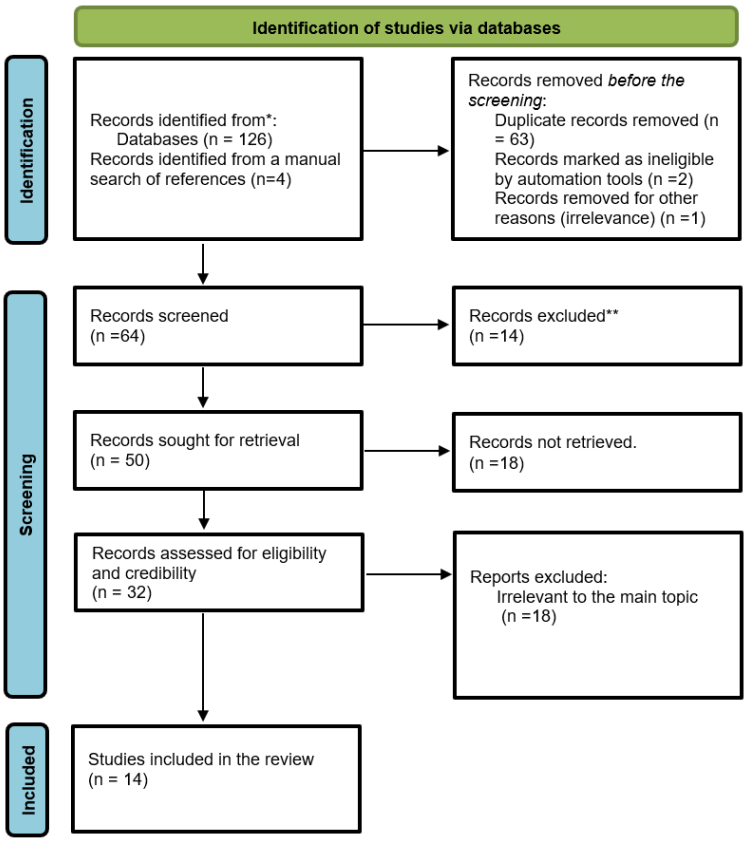

Figure 1:PLASMA diagram showing the search strategy.

The PLASMA flowchart, depicted in Figure 1 provides a clear and concise visual representation of the search strategy, screening process, and article selection.

The articles selected for their relevance to the research are shown in Table 1 which summarizes their content.

Table 1. Summary of the chosen studies pertinent to the topic and the various aspects they address.

Reference	Objective	Methodology	Results
Rómulo Jacobo et al, 2022	To analyse the perception and predisposition toward the support of citizens on the impact of sport tourism from a multidimensional perspective	Descriptive study, Survey	the study variables are significant except for social impact.
Cheung et al., 2016	Provide an analysis of tourist athlete expenditures and their subsequent economic impact, as well as their perception of the venue hosting the small-scale international sporting event	Experimental study	There is a positive impact on the destination's image and economic benefits for the community to host an international small-scale sport event.
Morfoulaki et al., 2023	To analyse the current and future potentials of sport tourism in the area's sustainable growth.	Case study and review	Sports tourism is estimated to help build a unique identity closely linked to sustainability goals.
Tomino et al., 2020	To review and systematize a broad spectrum of social impacts that outdoor sport-tourism events create from the perspective of key stakeholders and address strategic planning elements necessary for achieving event sustainability.	Systematic review	The previous assertions that most of the focus was on positive and economic impacts.
Perić, 2018	To understand the legacy of the 13th EHF European Handball Championship, held in Croatia in January 2018, by assessing the event's economic and social benefits and costs	Exploratory factor analysis	Community development and pride, security risks, traffic problems, economic benefits, environmental concerns, and economic costs are the primary impact dimensions.
Diedering, & Kwiatkowski (2015)	The main objective of this article is to review the international literature on the economic impact of sports events, and, in particular, to examine the key features of primary economic impact studies and potential sources of bias.	A systematic review of the literature	This paper provides an overview of studies on the economic impact of events and serves as a reference guide for further studies, including empirical ones.
Nyikana & Tichaawa (2018)	This paper explores sports tourism and its contribution to local economic development (LED) in an emerging destination context.	Mixed-method research design	Data reveal that by and large, sports tourism contributes significantly to LED and plays a vital role in the promotion of the region.
Poczta et al. (2020)	To investigate the influence of non-mega sporting events on the perception of negative externalities of host residents	Case study	The elite equestrian sporting event is less burdensome for its residents and gives them more satisfaction.
Kozhokulov et al. (2019)	To examine the socio-economic impact of tourism in the region	Quantitative assessment methodology	The study showed that the impact of tourism on economic and social growth in the Issyk-Kul region is positive.
González-García et al. (2018)	To develop a valid scale to measure residents' perceptions of the impacts generated by sport tourism activities	Descriptive study	The analysis results obtained a five-factor model with 16 items divided into (1) economic impacts, (2) cultural impacts, (3) environmental impacts, (4) social impacts and (5) political impacts.
Njoroge et al. (2017)	To evaluate the role of devolution in promoting sports tourism in Kenya and how sports tourism has contributed to social and economic development in the region.	Case study and survey	sports tourism has both positive and negative impacts on the destination

Tsekouropoulos et al. (2022)	To connect the local, sustainable tourism development with the sporting events and to come up with relevant proposals for the reference area and their generalization in the whole tourist areas.	Quantitative study	Several variables, such as the economic impact, can predict the acceptance of sustainable tourism development through sports.
Tzoumaka et al. (2022)	To explore direct spending profiles of sport event tourists in a small rural destination as an alternative to the economic impact of the multiplier effect studies.	Online survey method	The participants who responded to the survey spent, on average, about EUR 163 for accommodation, EUR 205 for meals, and EUR 38 for other tourist spending, such as souvenirs.
Peeters et al. (2014)	To use monthly country-by-country arrival data to assess the impact of organizing the FIFA 2010 World Cup on tourism in South Africa	Data analysis	South Africa attracted around 220,000 extra arrivals from non-Southern African Development Community (SADC) countries during the event, and 300,000 over the entire year. These numbers are less than the predictions made by the organizers prior to the event

In order to extract information from the articles, a categorisation table was drawn up based on the following dimensions: Line of search and the study references.

Table 2. Line of research covered by the studies reviewed for this paper.

Line of Research	**Study**
Explore the perceptions of local residents regarding the economic impact of sports tourism on their region	Rómulo Jacobo et al. (2022), Cheung et al. (2016), Bazzanella (2019), Kozhokulov et al. (2019), Peric, (2018)
To determine the relationship between sports tourism and the economic impact on a region.	Tsekouropoulos et al. (2022), Tzoumaka et al. (2022), and Kozhokulov et al. (2019), Perić (2018), and González-García et al. (2018)
Investigate the economic impact of small-scale sports events on the host region, considering factors such as infrastructure utilization and government investments.	Duglio & Beltramo (2017), Morfoulaki et al. (2023), Duglio & Beltramo (2017), Gibson et al., 2003, Fernández-Martínez et al. (2022), Gibson et al., 2003.
Assess the economic impact of large-scale or mega-sport events on the host region, taking into account the scale, investments, and crowd management.	Tomino et al., 2020, Vilakazi et al. (2014), Emery, 2002, Preuss, 2006
Examine the actual tourism influx numbers during the FIFA World Cup 2010 and identify the factors contributing to deviations from expected values, offering insights into event-specific challenges and opportunities.	Peeters et al. (2014), Ferreira, S. (2011). Briedenhann 2011, Knott, Brendon & Allen(2012) and Maennig & du Plessis, (2010).

RESULTS

The review of the selected studies provides valuable insights into the multifaceted relationship between sports tourism and regional economies. Rómulo Jacobo et al. (2022), Cheung et al. (2016), González-García et al. (2018), Tsekouropoulos et al. (2022), Bazzanella (2019), Kozhokulov et al. (2019), and Peric (2018) contribute to the understanding of residents' perceptions of sports tourism, revealing a range of viewpoints. Someone highlight the positive effects of sport tourism on community engagement, while others express concerns about resource allocation and disruption. Additionally, Tsekouropoulos et al. (2022), Tzoumaka et al. (2022), Kozhokulov et al. (2019), and Perić (2018) establish a clear link between sports tourism and economic impact, showcasing the potential for revenue generation, job creation, and infrastructure development in host regions. Furthermore, Duglio & Beltramo (2017), Morfoulaki et al. (2023), Gibson et al.

(2003), and Fernández-Martínez et al. (2022) illustrate that even small-scale sport events can significantly boost local business activity and tourism, emphasizing their economic significance. Conversely, Tomino et al. (2020), Vilakazi et al. (2014), Emery (2002), and Preuss (2006) shed light on the economic impact of mega sports events, such as the FIFA World Cup, which, while offering substantial economic benefits, also pose challenges such as high infrastructure costs and long-term sustainability concerns. Finally, Peeters et al. (2014), Ferreira, S. (2011), Briedenhann (2011), Knott, Brendon & Allen (2012), and Maennig & du Plessis (2010) delve into the specifics of tourism influx during the FIFA World Cup 2010 and the factors contributing to deviations from expected values, emphasizing the role of global economic conditions, host country perceptions, and event logistics. These findings collectively underscore the necessity for a nuanced approach to sports tourism management, taking into account the scale of events, residents' perspectives, and the intricate economic dynamics at play to maximize the positive impacts while addressing potential challenges.

DISCUSSION

The objective of this review is to critically analyse recent literature regarding the relationship between sports tourism and its economic impact on specific regions. In this discussion, we will examine how various studies address the phenomenon of sports tourism and its impact on the regional economy, emphasizing comparisons and contrasts between them.

Residents' perception of the economic impact of sport tourism

Several studies have explored residents' attitudes towards sports tourism, particularly when they perceive it as beneficial for the community, aligning with the social exchange theory. To begin with, Bazzanella's (2019) post-event analysis approach is recognized as a valuable tool for evaluating these perceptions. The objective of their research is to explore the perspectives of event stakeholders regarding sports events, with a specific emphasis on the involvement of residents in a tourist destination. In their finding from a qualitative analysis, the survey results indicate an overall sense of contentment among both residents and other stakeholders regarding the tourist destination.

Similarly, Kozhokulov et al. (2019) emphasize the significance of securing residents' support for the tourism industry by thoroughly comprehending their viewpoints, a pivotal element for the sector's long-term viability. In their research, the results suggest that residents who feel engaged and informed about tourism developments in their area are more likely to be supportive of the industry's growth and sustainability. Additionally, their study highlights that involving residents in decision-making processes related to tourism planning can foster a sense of ownership and responsibility, leading to a more harmonious coexistence between tourism and the local community.

Furthermore, Rómulo-Jacobo et al. (2022) introduces a new perspective that assessing residents' perceptions promotes social engagement and inclusivity, fostering a more favourable disposition toward sports tourism and inclusive sports. According to their findings, they conclude that analysing the social perception of citizens and assessing the impact of sport tourism on their support for tourism development can prove highly valuable in shaping policies geared toward fostering social cohesion and local development.

However, Peric (2018) points out a significant gap in the approach to sports event tourism in his discussion, he argue that while much attention has been given to the events themselves, relatively less focus has been placed on the tangible benefits that local communities can derive. This perspective highlights the need to prioritize the interests and advantages that residents gain from hosting sports events. The success of such

events, as Peric suggests, is intricately linked to the degree of support and perceived benefits from the local community's perspective.

In contrast to the prevailing residents' positive views on the impact of sports tourism, Cheung et al. (2016) presents a dissenting perspective. They argue that while sports tourism may bring economic benefits to a destination, it often comes at the expense of local residents' quality of life. They contend that increased tourist traffic can lead to overcrowding, environmental degradation, and a rise in the cost of living, which can negatively affect the well-being of the host community. Cheung et Al's research emphasizes the importance of carefully assessing the trade-offs between economic gains and potential social and environmental drawbacks when considering the promotion of sports tourism. This perspective urges a more cautious and balanced approach to ensure the sustainable development of both the tourism industry and the local community.

Contribution of sport tourism to the economy of a region

In the context of sports tourism, the term "*economic impact*" encompasses the wide-ranging economic transformations occurring within a local economy due to the expenditures associated with specific activities, as outlined by Andreff in 2006. Notably, several researchers, including Tsekouropoulos et al. (2022), Tzoumaka et al. (2022), Kozhokulov et al. (2019), Perić (2018), and González-García et al. (2018), have explored these impacts, categorizing them as either positive or negative.

Perić's 2018 study, for instance, primarily focuses on the positive aspects of these impacts, particularly honing in on the concept of "*direct spending*." Direct spending is a widely recognized metric used to gauge the contribution of sports tourism to the local economy. Perić's research elucidates that direct spending translates into tangible benefits, such as revenue generation and job creation, thereby bolstering the overall economic vitality of the region in question. This underscores the pivotal role that sports tourism can play in not only enhancing a destination's financial well-being but also in fostering employment opportunities within the community.

Another crucial focus on sport's contribution to the economy is the study carried out by Nyikana & Tichaawa (2018) "*Sport Tourism as a Local Economic Development Enhancer for Emerging Destinations"*. The study imparts essential insights for local government bodies and pertinent stakeholders in the tourism and sports sectors regarding the development of policies and strategic planning for sport tourism events. It underscores the importance of local authorities taking proactive measures to harness sport tourism events to their fullest potential, thereby expanding the array of economic benefits that accrue to the community.

Another noteworthy contribution of sports tourism to the host region lies in infrastructure development. Tomino et al. (2020) concur that hosting sports events often necessitates investments in infrastructure, encompassing new or upgraded stadiums, arenas, transportation networks, and accommodations. These investments can yield long-term economic benefits by enhancing the region's appeal to both visitors and businesses. Job creation is another substantial economic impact of sports tourism, as emphasized by Njoroge et al. (2017), hosting sports events generates employment opportunities across various sectors, including hospitality, tourism, transportation, and construction, thereby contributing to the overall economic growth of the region. Crompton (2006) further supports the idea that sports tourism significantly enhances the region's visibility, fostering media coverage and publicity that promote the region's image, attract future visitors and businesses, and subsequently boost tax revenue—making tax revenue a key metric for quantifying the economic impact of sports tourism in a host region.

In contrast, Tzoumaka et al. (2022) introduce a distinct perspective in their research, underscoring the importance of considering various factors when evaluating the overall financial impact on the host destination. They emphasize the significance of accounting for elements such as leakages from the local economy, opportunity costs, and the multiplier effect. This viewpoint aligns with the findings of Njoroge et al. (2017), who also shed light on the potential negative repercussions linked to tourism development. In their study titled "*Sports Tourism and Perceived Socio-Economic Impact in Kenya: The Case of Machakos County*," they highlight some of the adverse economic consequences associated with hosting sports events, including increased living costs, potential fluctuations in temporary employment, and inflationary pressures.

The economic impact of hosting small-scale sports events

The study of the economic impact of hosting small-scale sports events is a pivotal focus area within sport tourism research. Gibson et al. (2003), explain that small-scale sports events encompass sporting competitions or activities characterized by a limited number of participants and spectators, often taking place at the local or regional level. These events, such as community fun runs, local soccer tournaments, or regional youth sports leagues, typically foster an intimate and community-centred atmosphere. According to Gibson et al. (2003), They often attract less media attention and involve lower financial investments compared to large-scale sports events. Nevertheless, despite their smaller scale, small-scale sports events can exert significant social and cultural influences on local communities and offer athletes valuable opportunities for competition and skill development (Parra-Camacho et al. (2021).

Numerous studies, including works by Duglio & Beltramo (2017), Morfoulaki et al. (2023), Duglio & Beltramo (2017), Gibson et al., 2003, Fernández-Martínez et al. (2022), have conducted comprehensive analyses of the potential benefits that small-scale sports events bring to host destinations.

To begin with, a study by Gibson et al., (2003) involves comparisons of the economic impacts between large and small-scale events. In their study, "*Small-scale event sport tourism: fans as tourists",* they discuss extensively how sports events serve as major tourist attractions for destinations, and how the cancellation of such events can result in substantial financial losses. Once crucial aspect covered by this study is the comparison between small-scale and large-scale events. Gibson et al. (2003) provide data and analysis showcasing how even smaller, niche sports events can have a considerable impact on tourism and the local economy. This finding suggests that smaller communities could maximize their tourism advantages by capitalizing on the events to attract fans of the visiting team.

A study by Morfoulaki et al. (2023) shifted its focus towards sustainability concerns pertaining to small-scale sports events and their implications for host destinations, with particular attention to rural or peripheral areas, as opposed to urbanized regions. In their study Morfoulaki et al. (2023) have illuminated how small-scale sports events can create sustainable tourism opportunities for communities, particularly in smaller locales where event stakeholders frequently comprise members of the local community itself. Further, their findings reveal that sport tourism plays a significant role in shaping a distinctive identity closely aligned with sustainability objectives of a given region, with a focus on small-scale sport events.

The findings of Duglio & Beltramo (2017) are situated among the studies indicating that hosting international small-scale sports events can enhance the reputation of the destination and yield economic benefits for the local community. This perspective finds further support from Fernández-Martínez et al. (2022), who contend that organizing small- and medium-sized sports events, such as the Media Maratón Ciudad de Granada (Granada Half Marathon), can serve as an effective strategy for promoting sustainable tourism within the local community. Sustainable tourism, as espoused by the authors, takes into account a range of factors,

including economic, social, and environmental aspects, while considering the needs of residents, visitors, and the industry, both in the present and for the future.

Gibson et al. (2003) and Parra-Camacho et al. (2021) propose that the definition of small-scale events should be approached relatively, as current definitions encompass both local sporting competitions with community support and those that attract participants and audiences at the national or even international level. Moreover, smaller events typically demand fewer public resources, rendering them an appealing option for communities seeking to host sports events within limited budgets.

An opposing perspective questions the unquestionable positive influence of such events, as argued by Fernández-Martínez et al. (2022). One pressing issue raised by this study pertains to the costs incurred when hosting small-scale sporting events. They argued that, despite their smaller scale compared to mega-events, these occasions demand resources for infrastructure, security, and organization. In certain instances, these costs may outweigh the economic benefits. An instance this study uses is when a local community invests in constructing or renovating facilities for a small-scale event, the return on investment may not be favourable, particularly if these facilities remain underutilized outside of the event, leading to an unfavourable cost-benefit imbalance that can strain local budgets.

Moreover, concerns have been expressed regarding the displacement effect. Duglio & Beltramo (2017) further argue that small-scale events can divert resources and attention away from other sectors that may offer more substantial and sustainable economic contributions to the community. Funds allocated to host a small-scale sporting event could have been potentially channelled into long-term infrastructure improvements or investments in industries capable of generating consistent economic benefits beyond the event's duration.

Additionally, critics by Gibson et al. (2003) contend that the economic benefits of small-scale events may not consistently benefit the local community in a meaningful way. In instances where these events predominantly draw participants and spectators from outside the host community, economic gains may flow out of the area rather than bolstering local businesses and residents. As they point out in their study, this phenomenon, often referred to as "*leakage*," can limit the positive economic impact on the host community.

The economic impact of hosting major sporting events

Major sporting events, often referred to as mega sports events, are characterized by their global reach, substantial revenue generation, and significant infrastructure investments. Examples include the Olympic Games, the FIFA World Cup, the Super Bowl, and the Tour de France. These events span multiple sports, occur over extended periods, and attract athletes from around the world.

One critical aspect highlighted in the literature is the dual nature of major sporting events. While they offer the potential for significant economic benefits to a region, they also come with immense resource consumption and exposure to substantial risks, this according to a study by Emery, (2002) "*Bidding to host a major sports event: The local organizing committee perspective*." He further argue that the cost of hosting such events is considerable and necessitates a thorough examination of their economic impact. Preuss, (2006) is also in the agreement that the allocation of substantial public funds to major sports events underscore the need for a comprehensive understanding of their impact on a region's economy.

A study conducted by Vilakazi (2014) aimed to compare the economic impacts of small-scale sports events with those of major sporting events. The research revealed intriguing findings highlighting the unique dynamics of these two categories of events. Major sporting events, while indeed delivering significant

economic benefits, also came with immense resource consumption and higher costs of organization. The study emphasized that the choice between hosting a small-scale event or a major one should be based on a careful consideration of the specific goals and resources of the host region, as each type of event offers distinct advantages and challenges in terms of their economic impact.

According to a recent study by Tomino et al., (2020), it is important to recognize the expenses associated with organizing major sporting events, which can place a significant financial burden on the host country's government. And Vilakazi (2014) strongly supports this notion by pointing out further that these major sporting events' expenses include infrastructure development for transportation, venue design, and accommodation for players and spectators.

While major sporting events offer international recognition and popularity (Peric 2018), they also present complex economic dynamics. Despite potential adverse outcomes, the anticipated positive impacts continue to drive demand for hosting such events (Peric, 2018). Consequently, a substantial body of research has concentrated on major sporting events due to their significance and influence on the global stage.

Here is a case of the FIFA World Cup 2021 and its economic outcomes to South Africa.

Case study: Assessing the tourism industry and economic outcomes of the FIFA World Cup 2010

Several studies, such as Peeters et al. (2014), Ferreira, S. (2011) and Du Plessis and Maennig (2010) have conducted investigations to assess the achievement of tourism industry and economic goals during the FIFA World Cup 2010. These studies present evidence suggesting positive outcomes.

To begin with, Peeters et al. (2014) conducted a comparative analysis of national monthly tourist inflows in South Africa and other countries worldwide. Their findings indicate that the World Cup played a significant role in attracting an additional 294,804 tourist arrivals in 2010, representing a 12% increase compared to previous years. This increase in tourist arrivals contributed to additional revenue generated in the tourism sector.

Du Plessis and Maennig (2010) estimated a net increase of 40,000 to 80,000 tourist arrivals. These findings were in agreement with that of Peeters et al. (2014) which highlights the substantial discrepancy between the anticipated and realized levels of tourist arrivals during the FIFA World Cup 2010.

In 2010, South Africa hosted the World Cup and witnessed a total of approximately 360,000 domestic and foreign tourists, as reported by Knott, Allen, and Swart (2012). However, it is important to note that the actual number of tourist arrivals fell short of the original expectations, as mentioned by Briedenhann (2011) and Peeters et al. (2014). Among the foreign tourists, the FIFA (n.d.) reported that 176,000 individuals travelled from participant countries to support their national teams and participate in the World Cup. Additionally, there were approximately 46,000 visitors from non-participant nations, further contributing to the tourism influx during the event.

The deviations in the number of tourists during the FIFA World Cup 2010 can be attributed to various factors. Economic conditions, including global recessions and financial constraints, may have impacted individuals' travel decisions Briedenhann (2011). Concerns over safety and security, along with the perceived safety of South Africa as a destination, could have influenced tourists' choices. Travel costs and accessibility, such as high expenses and limited transportation options, may have deterred potential visitors. The presence of competing events or attractive destinations could have drawn tourists away from South Africa.

CONCLUSION

In conclusion, the reviewed studies collectively support the notion that sports tourism holds substantial positive economic potential for regions. Hosting sporting events not only lures tourists but also paves the way for job creation and local business revenue. Importantly, these economic advantages are not confined to the short term but can extend their influence over the long run by elevating the region's reputation and fostering sustained tourism growth.

However, it is essential to acknowledge that there are also authors who have pointed out the potential negative impacts of sports tourism. Thus, it becomes evident that both small-scale and major sports events have the potential to significantly influence a region's economy. Small-scale events may have a more localized impact, whereas major events can draw a larger number of tourists and generate greater revenue. Yet, the successful realization of these benefits relies heavily on careful planning and management to maximize economic advantages while minimizing any potential drawbacks.

Furthermore, ongoing research remains pivotal in fostering a deeper understanding of and management strategies for potential adverse consequences, ensuring that regions can harness the full potential of sports tourism while effectively addressing its challenges in this ever-evolving landscape. Continued exploration and knowledge-sharing will undoubtedly play a vital role in guiding regions towards realizing the benefits of sports tourism while mitigating its potential downsides.

AUTHOR CONTRIBUTIONS

The collaborative effort of the authors in this publication was characterized by distinct and complementary contributions, showcasing a well-coordinated team effort. Each author played a crucial role in different aspects of the research and development process.

Giovanni Raso played a pivotal role in conceptualizing the research framework. His expertise in Sport Science and management shaped the overarching research questions and guided the study's direction. Additionally, Raso Giovanni led the design of the study methodology and oversaw the data collection process in the field. His hands-on involvement ensured the robustness of the data gathered.

Dr. Cherubini took the lead in drafting the manuscript, synthesizing contributions from all authors into a cohesive narrative. His expertise in research write-up ensured clarity and precision in communicating our research methods, results, and conclusions. Additionally, Dr. Domenico played a crucial role in the review and editing process, incorporating feedback from all authors to refine the final manuscript.

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SCIENTIFIC JOURNAL OF SPORT AND PERFORMANCE

REVIEW ARTICLE

Comprehensive approach to physical skill in different age groups in sports games: A review

Blerina Mema. *Department of Education and Health. Faculty of Movement Science. Sports University of Tirana. Albania.*
Enkeleida Lleshi ✉ **.** *Department of Sports Performance. Sports Research Institute. Sports University of Tirana. Albania.*

ABSTRACT

The formation of young athletes is very important and for this it is necessary to build appropriate training programs that help them grow, develop to have results in sports activities in which they participate. Methods: This literature review was conducted in accordance with the guidelines for meta- analyses of (Tricco et al. 2018), to address the research questions. To collect the data for our study, 4 bibliographic databases (PubMed, Scopus, Web of Science and Pro Quest) were used using the Jab Ref program. Results: From 105 articles in incompatibility with the concept of dexterity, speed, strength, coordination only 23 scientific articles that matched our requirements remained for our study. Conclusions: From this study some light can be shed and some recommendations can be made to guide future research efforts. Data from several studies have identified that combined training programs can be considered a safe and successful method when working with adolescents. Training and testing of athletes must be structured in specific ways. Assessments are important for coaches to identify athletes' strengths and weaknesses in order to adapt and apply the appropriate training method. Comprehensive assessments are needed to draw conclusions about the origins of changes in agility and coordination performance.

Keywords: Sports games, Training programs, Speed, Strength, Agility.

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✉ **Corresponding author.** *Department of Sports Performance. Sports Research Institute. Sports University of Tirana. Albania.*
E-mail: elleshi@ust.edu.al
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INTRODUCTION

Early childhood marks the beginning of the development of the first motor movements. Children develop gross motor skills, which include movements that rely on the coordination of the large muscles of the body, such as: walking, grasping, climbing and jumping, motor skills that children develop in the first stages of life and that are perfected with age. Also, during early childhood, they develop fine motor skills that are small and precise movements (Bompa & Carrera et al. 2015). Both gross motor skills and fine motor skills are practiced and learned during their daily lives, in kindergartens or at home, while they run, play, catch and throw different objects says (Bompa & Carrera et al. 2015). When working with children aged 11 - 14 years, it is recommended that the training intensity be increased to improve athletic performance. At this stage of their development, some athletes are likely to show a growth spurt (a 14-year-old playing sport can show large changes in physical potential similar to that of a 16-year-old), according to (Bompa & Carrera et al. 2015) and as a result manifest a lack of coordination during training. At this stage, the emphasis must fall on improving the qualities and skills of athletes and not on physical performance or winning during competitions/matches. To achieve the most satisfactory results according to (Bompa & Carrera et al. 2015), it is important to consider some guidelines such as:

- The combination of a series of exercises that are related to the specificity of the sport they practice as well as other sports, increasing both the intensity and the volume of training;
- The use of a series of exercises that will help young athletes perfect the basic skills learned so far and develop complex skills that affect the improvement of concentration;
- Emphasis is placed on the training of coordination, flexibility, and balance;
- Inclusion in training programs of exercises that develop in young athletes general strength, power, aerobic capacity and endurance as well as moderate anaerobic training that prepares young athletes to cope with high-intensity anaerobic training that helps during the specialization phase.

The formation of young athletes is very important and for this it is necessary to build appropriate training programs that help them grow, develop to be healthy and have high results in sports activities in which they participate. According to (E. Lleshi & V.Rizvanolli 2014) in their scientific research, have analysed separate aspects of the jumping ability development of volleyball players through the employment of special exercises in the training process. According to (E. Lleshi & V. Rizvanolli 2014) achievement of high results in the development of these components depends on the employment of a special evaluative test system in the training process, which will evaluate the muscle strength and jumping ability of athletes at any stage of the training process. According to authors (Asfour, H. R. et al 2022) recommend the use of harmonic abilities due to their positive impact on skill performance in volleyball. Furthermore, encouraging coaches and those in charge of the training process to use and develop harmonic abilities exercises is crucial, as they are an important, effective, and influential part ofimproving and developing the skill performance of volleyball players according to (Asfour, H. R. et al 2022).

The stages of development of each child are different and are accompanied by physical, psychological, emotional and cognitive changes, for this reason, the training program must be suitable for each stage of development. It is known that children of the same chronological age show differences in biological growth. The study by (Jukic et al. 2021) shows that it is important that when we evaluate the age of athletes, we should consider: chronological age; biological age in young athletes; metabolic age; sports age which refers to the years of activation in organized sports. Biological age is a very important factor in the development of organs and systems in the human body and determines and helps increase the level of physical performance both during training and competition. Therefore, coaches should consider the biological age of children when selecting athletes and when planning training programs, as it can often happen that two athletes may have

the same age, height, weight and musculature but they are biologically different and exhibit different skills to perform a required exercise. For these reasons, it is important to assess individual differences in biological age according to (Bompa & Carrera et al. 2015). Also, it is worth taking into consideration the age and gender of the athletes as only in this way we will be able to achieve a satisfactory and efficient sports preparation indicated by (Lloyd & Oliver et al. 2012).

The methods and effects of agility training are thought to vary with biological age. Recommendations regarding age-appropriate agility training are largely speculative due to the lack of literature in this area according to (Jeffreys et al. 2019). Data from several different studies suggest that agility performance naturally improves with age (in addition to training), especially from childhood to adolescence according to (Zemková & Hamar et al. 2014). (Harrison & McGuigan et al. 2019) they say that adaptation of training to improve agility is not attributed alone to influences of exposed trainingstimuli but also the natural processes of development of young athletes.

It is difficult to distinguish between natural development and adaptations from exercise in young athletes say (Matos, N., & Winsley, R. J. 2007).

From what was said above, we conclude that it is necessary to take into account the aspects of growth and maturation of young athletes by regularly monitoring body height and mass, as they affect both the ability to train and the natural development of dexterity during childhood and adolescence (Harrison & Mc. Guigan et al. 2019). The stages of training development should correspond to the children's biological development. Thus, pre-puberty is the stage of beginning training, in this stage athletic training takes place; post-puberty is the stage of training specialization and the maturation stage where the highest performance is achieved.

Referring to the sports games and the age of the athletes that we will take for the study, according to (Bompa & Carrera et al. 2015), in the sport of basketball, the pre-puberty phase that is the beginningof training coincides with the age of 10-12 years, the post-puberty phase where they specialize at theage of 14-16 years and in the maturation phase where the highest performance is achieved, at the age of 22-28 years. In the sport of volleyball, the pre-puberty phase coincides with the age of 10-12 years, the post-puberty phase coincides with the age of 15-16 years and the maturity phase coincides with the age of 22-26 years. In the sport of football, it is observed that the stage of development of pre-puberty (10- 12 years old) and post-puberty (14-16 years old) is the same as in the sport of basketball, while the maturation stage where the highest sports performance is achieved coincides with the age of 22 – 26 years old as in volleyball players according to (Bompa & Carrera et al. 2015). According to the study of (Naughton et al. 2000), it is emphasized that in the preadolescent age, the physiological adaptation is likely to be different from the physiological adaptation of adults after the implementation of an exercise program.

Today, scientific research related to modern training programs and applied to young people may still be in progress in Albania, but the evidence base that is progressively accumulating over the year's shows a growing research activity and interest in this topic in Europe. According to a pilot study conducted in Tirana Albania (Mema, B. & Lleshi, E. 2023), the results indicated children's volleyball agility improvement of the skills scores can be achieved with a specific training model to help players improve their skills. According to (Mema, B. & Lleshi, E. 2023) show the training process of children volleyball players in Association Sports Tirana in Albania is conditioned by the factor available to develop training sessions with a specific training purpose.

This review of the literature about the models of training programs in young groups is a step toward the

selection of the most effective methods of sports training in age groups in sports.

Also, this literature review is expected to reveal data gaps and future research efforts as well as the determination of evidence related to training ability, natural development and the contribution of the main performance factors of motor skills in young people.

METHODS

This literature review was conducted by the guidelines for meta-analyses of (Tricco et al. 2018), to address the research questions. This study did not need ethics board approval as the data collected was obtained from previous studies that had ethics board approval. The study data were processed using Microsoft Excel 2019. To collect the data for our study, 4 bibliographic databases PubMed, Scopus, Web of Science and ProQuest were used using the JabRef program, as adaptive sources for the review of the literature. The title, abstract, and keyword fields were searched with search terms that included the speed, agility, strength, coordination and training programs. Eligible publications had to comply with several criteria, which were: peer-reviewed articles, books, conference proceedings, doctoral theses, articles written in English, results related to the ability to train young people, and the presence of diseases or injuries that could affect the reported results, so we only included studies that had healthy subjects. Studies that did not fit the inclusion criteria were removed from the list. If screening of the title and abstract did not provide adequate information about agility, speed, coordination, and strength, the full article was read to verify eligibility.

RESULTS

Data extracted from the review of various articles were collected and analysed. Publication characteristics (year of publication, type of study), study characteristics (age, maturity stage, gender, type of sport, performance level), and study characteristics (sample size, measurements) were enteredinto the Microsoft Excel system.

The results of the search and selection process are in total of 105 scientific articles were collected in PubMed, *n* = 21; Web of Science, *n* = 28; ProQuest, *n* = 20 and Scopus, *n* = 36.

Out of 105 articles were excluded according to the following criteria:

- Incompatibility with the concept of agility, speed, strength, coordination (*n* = 34),
- The age group studied (*n* = 17),
- Absence related to content (*n* = 23),
- Insufficiency of the information provided (*n* = 8).

Out of 105 articles, only 23 scientific article researchers that matched our requirements remained for our study.

DISCUSSIONS

The most significant result in the study of (Fathi et al. 2018), was that in adolescent male volleyball players, a 16-week program of combined strength and plyometric training was generally more effective for reducing body fat percentage, improving 5m and 10m sprint times, and improving the performance of muscle power than plyometric training alone while muscle flexibility was unchanged. Also, combined exercise produced positive changes in both body mass and body fat percentage. Data from several studies have identified that

combined training programs can be considered a safe and successful method when working with adolescents. Strength training can induce morphological changes (Legerlotz et al. 2016). According to the study conducted by (Fathi et al. 2018), the combined training program significantly reduced sprints (S5m and S10m) by 0.05 seconds (ES: 0.69; 6.47%; p = .001) and 0.07 seconds (ES: 0.31; p = .001), 3.47%; p = .001).

Therefore the authors (Fathi et al. 2018) in their study included exercises consisting of simultaneous triple stretching of these joints, combining half-squat and Bulgarian squat split with vertical jumps and showed that their impact on sprint performance was positive.

When the natural growth of children which is associated with the development of the central nervous system and neural coordination during the childhood period, is combined with plyometric training according to (Loturco et al. 2015), may result in an enhanced exercise response according to (Fukutani et al. 2014).

Some authors (Lloyd et al. 2016, and Philippaerts et al. 2006) have shown an improvement in power and strength performance in approximately 0.5 - 1.0 years, which is comparable to the findings also in the study conducted by (Fathi et al. 2018). Another study has shown that exercises requiring a high levelof reactive force and maximum running speed (in boys) according to (Radnor et al. 2017) showed satisfactory results after combined training and traditional strength training.

Other studies have shown the importance of natural growth and development, training and various tests for determining agility in youth according to (Hojka & Inglis & Bird et al. 2016); (Lloyd et al. 2013), (Paul et al. 2015). However, the effects of growth and maturation were not considered in the literature review. Trainability and the natural development of dexterity with growth and maturation have been narrowly reviewed, leaving room for other more in-depth studies according to the authors (Jeffrey et al. 2019), (Lloyd et al. 2013) and (Oliver & Lloyd et al. 2017).

CONCLUSIONS

Current practical data on the effectiveness of training programs in team sports in age groups can be said to be still limited as a gap in scientific articles is evident. For this reason, in Albania, more research and evidence are needed to better understand the different factors that influence the increase in sports performance among age groups.

Based on the literature found on dexterity, different performance-determining factors have been identified such as perceptual and decision-making factors and technical and physical qualities. However, the contribution of these factors depends on the tests used to assess the skills and the environment in which the tests are performed. Studies suggest that the relationship between agility performance and physical qualities depends on the age of the athletes.

Moderate to high relationships between jump performance and agility and those between sprint performance and agility were observed in the U11 - U14 age groups. The rather high correlations observed may result from the generic stimuli applied in the dexterity tests. The influence of physical capacities is more pronounced in the changes of direction of speed "*CODS*", in which the perceptual and cognitive demands are mostly overlooked. Physical qualities are generally more related to CODS than agility performance.

The age factor is important in sports training. Some authors reported a decrease in physical associations (i.e.

jumping, sprinting and "*CODS*" performance) and agility performance with increasing age groups, since in adulthood; physical qualities and agility are poorly correlated. Factors other than physical capacity (i.e. technical, perceptual and cognitive factors) are increasingly related to agility performance in older age groups, supported by findings in sprint and jump performance.

Movement technique, perceptual and decision-making factors are of greater importance for agility performance in adults. Otherwise, among young athletes, physical qualities seem to be more decisive. Because of their age, younger athletes exhibit less game experience and shorter training history, resulting in lower perceptual and decision-making skills, inexperienced technique, and a lack of movement strategies than older athletes. The relationships between agility and sprint, jump and CODS performance were more pronounced in U15 athletes than in U14 athletes, contradicting the aforementioned findings.

The authors assumed that the older group possessed a higher level of technical skills due to longer involvement in training, which enables them to utilize their running and jumping qualities to a greater extent and convert them into manoeuvres effective agility. Age, gender, training frequency, training experience, body mass in girls and peripheral perception in boys were identified as contributing or impairing factors.

AUTHOR CONTRIBUTIONS

The contribution to this review is joint, where Blerina Mema is a PhD candidate and Enkeleida Lleshi is her scientific leader.

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ORIGINAL ARTICLE

FIFA World Cup 2022 and Bangladesh: Shedding light from the sociology of sport

Anisur Rahman Khan . *Department of Sociology. East West University. Dhaka, Bangladesh.*

ABSTRACT

The FIFA World Cup is the most exalted sporting event in the globe. Although Bangladesh is not historically a great football-playing nation and has never been any close to the final stage of World Cup qualification, the FIFA World Cup matters so much for Bangladesh. This content analysis is an effort to understand the implications of the FIFA World Cup 2022, held in Qatar, in Bangladesh from the standpoint of the sociology of sport. News, events, opinions and activities published in various national and international online English news portals capturing the connection between the FIFA World Cup 2022 and Bangladesh have been analysed. Findings have been categorised and analysed according to the essence of the major theoretical perspectives in sociology: functionalism, conflict theory and symbolic interactionism. Three theoretical perspectives in sociology offer meaningful explanations about the interface between the FIFA World Cup 2022 and Bangladesh. According to functionalism, the FIFA World Cup 2022 conveyed several beneficial consequences for Bangladesh. But some incidents of dysfunction were also noted. The ways Bangladeshi expatriate workers involved in World Cup-related construction projects were exploited and suffered has been explained by conflict theory. The whole of Bangladesh was inextricably connected with the FIFA World Cup 2022. This factor is explained by symbolic interactionism.

Keywords: FIFA World Cup 2022, Football, Qatar, Bangladesh, Sociology of sport.

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Corresponding author. *Department of Sociology. East West University. Dhaka, Bangladesh.*
E-mail: arkhan@ewubd.edu
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INTRODUCTION

Sport is integral to social and community life. It entails a key element in 'cultural universal' and represents to be one of the pivotal social institutions (Snyder and Spreitzer, 1974). Sociology critically examines sport as an essential social institution. In particular, the sub-discipline sociology of sport has been involved in academic pursuits to understand and analyse the varied aspects of sports at national and international levels (Giulianotti, 2015). Traditionally, sociology of sport emerged in response to the need for theory development and research on sport considering it as a rational and meaningful social interaction process (Lüschen and Hammerich, 1967). Subsequently, it has comprehended its attempts to scientifically capture the relationship between sport and culture/society. Also, the ways the behaviour of individuals and groups are shaped by sports as well as the rules and regulations associated with them (Delaney and Madigan, 2015). Sociology of sport meaningfully produces knowledge of the social and cultural contexts where sports exist, the experiences of groups and individuals associated with sports and the systems and organisations that govern and manage sports in society (Coakley, 2017).

The early sociological approach to the study of sport is due to German scholar Heinz Risse who published *Soziologie des Sports* (Sociology of Sports) in 1921 where the outlines and functions of sport were discussed (Lüschen and Hammerich, 1967). Risse's contribution was not recognised as an essential work although there was a heightened interest in sport as a phenomenon of mass entertainment during the 1920s. Sport as a social phenomenon was grossly devalued and only received a marginal space as a scientific pursuit (Giulianotti and Thiel, 2023). But it is only with the formation of the *International Sociology of Sport Association (ISSA)* in 1965 and its signature journal *International Review for the Sociology of Sport* which began publications in 1966, the study of sports gained momentum in sociology (Giulianotti, 2015). As of now, the sociology of sport has been widely visible internationally and scholars are showing a great deal of social and collaborative engagements to advance this sub-discipline in diverse ways (Giulianotti and Thiel, 2023). Furthermore, the development of a sociology of sport has boosted by the gradual expansion and rationalisation of sports through the twentieth century (Coakley, 2017).

FIFA (*Fédération Internationale de Football Association*), founded in Paris in 1904, arranges the men's football World Cup tournament every four years (Chankuna, 2022). The first event was kicked off in Uruguay in 1930 and the recent one in Qatar in 2022 from 20 November to 18 December. The FIFA Football World Cup, often simply called World Cup, is unquestionably the world's most popular and spectacular sporting event. Also, it is the world's most valuable, powerful and influential show/brand on the earth (Shultz, Castilhos, Fajardo, Grbac and Chatzidakis, 2015) that attracts a huge international audience, communication and coverage (Horne and Manzenreiter, 2006; Frawley and Adair, 2014). Any sports mega event such as the FIFA World Cup can entail significant positioning of the nations to international and global communities. Organising such an event is not only a matter of glory for the host country, but it also brings remarkable positive outcomes in terms of socio-economic returns (Horne and Manzenreiter, 2006). Of course, many negative consequences are also associated with this event (Al-Emadi, Sellami and Fadlalla, 2022). The world turns out to be the *Planet Football* during the final days of this event. Billions of people get connected to the event in numerous ways-being present physically in the stadia and/or via all print, electronic and social media and through social and public spaces (Shultz et al., 2015). FIFA's campaign, "*Football Unites the World"* stands as a signature mark to symbolise the power of this mega sporting occasion to bring people together, unite and celebrate together (FIFA, nd*a*.).

Bangladesh, a country located in South Asia, cuts a very poor figure in FIFA rankings in men's football. Currently (August 2023) Bangladesh holds the 189th position (FIFA, nd*b)*. This country has never been close

to qualifying for the FIFA World Cup and achieved very limited success at the regional-level tournaments. Winning the South Asian Football Federation (SAFF Championship) in 2003 is the most notable success of Bangladesh's men's football team. It also earned the gold medal in the 2010 South Asian Games (Rasul, 2021). Nonetheless, Bangladesh is a football-loving nation. Football was the most popular sport in the country. But the standard of the game started to decline from the late 1980s and onwards. The Federation and the clubs failed to professionalise the game with long-term plans and efforts. As a consequence, football gradually has lost its glory and old tradition (Bandyopadhyay, 2016). Despite the apparent stagnation of football along with poor international/regional performance, the people of Bangladesh get hyped during the FIFA World Cup. During the time of the tournament, the nation apparently gets divided into showing its immense loyalty either towards Brazil or Argentina. Football fever spreads across every corner of the nation, indicating people's deepest devotion and love towards football, the event and the supporting teams (Bandyopadhyay, 2016).

This article aims to analyse the socio-cultural implications of the FIFA World Cup 2022 on Bangladesh from the standpoint of sociology of sport. While attempting to explore the interconnectedness between the sociology of sport and the FIFA World Cup in the context of Bangladesh, the analysis is theoretically bounded by the three major perspectives of sociology. As the World Cup exerts a great influence on society and human behaviour, it is important to understand the extent of that influence in meaningful sociological ways.

THEORETICAL FRAMEWORK

Functionalism

Functionalism is associated with the works of several classical sociologists such as August Comte, Emile Durkheim, Herbert Spencer and Max Weber (Delaney, 2015). Later on, Talcott Parsons, developed and extended functionalism as a grand theory by synthesising the insights and thoughts of the noted sociologists (Ormerod, 2020). Parsons' functionalism, often called structural functionalism, infers that social system is a network of inter-related parts or subsystems which are arranged by accommodating all actors involved in achieving the goals of the system (Delaney, 2015). Precisely, according to functionalism, society is composed of various interrelated parts or structures working together to bring overall order, cohesion and stability to the social system (Khan, Naz and Khan, 2017). All social institutions (e.g. religion, politics, economics, education, family, sport, media and so on) are not only interlinked but also function in their own ways for maintaining the system (Delaney, 2015). Another influential sociologist, Robert Merton, described two types of functions for any social institution maintaining the social system: manifest/intended and latent/unintended/unplanned functions or by-products of the original intention. He also articulated the likely dysfunctional features of certain aspects of the social system. Dysfunctions disrupt the normalcy of the system (Delaney and Madigan, 2015).

Conflict theory

Conflict theory entails the assumption that power is fundamental to social relations. Competing groups struggle or engage in conflict for control of power. Power ultimately results in inequalities throughout society (Hayward, 2015). Conflict theory provides an important understanding of social structure, social problems and social change (Eitzen, 1988). This theoretical perspective is based on Marxist ideologies concerning class relations in the capitalist society and critically views alienation, injustices and oppression caused due to economic injustices in the society (Crossan, 2012). According to the Marxist thesis, the relations of production in capitalism give rise to conflict between economic classes. Following Marx, sociologists have extended the basic idea of Marxist conflict perspective to understand various group relationships and their sources of tensions. For example, Max Weber's model of social stratification, in addition to economic class, includes two other attributes: social esteem/status and power. While contemporary understandings of conflict

theory encompasses several sources of social inequalities based on race, gender, sexual orientation or inter-organisational competition (Simon, 2016).

Symbolic interactionism

Unlike functionalism and conflict theory, symbolic interactionism is a micro-sociological perspective that views society as the product of everyday interactions and communications (Khan et al., 2017). George Herbert Mead, the leading proponent of symbolic interactionism, views people develop their own identities through interactions with different apparatus of society. According to Herbert Blumer, social meanings are derived from interpersonal interaction. While, Ervin Goffman, through a dramaturgical approach, states social behaviour can be thought of as a staged performance in which the actors deliberately relay specific impressions to others (Berry, 2010). Through symbolic interactionism, the multiple identities of an individual are shaped through behavioural, cognitive and emotional interfaces with societal symbolic patterns and entities (Sartore and Cunningham, 2007). Interaction is symbolic, people use various symbols such as language, gestures/non-verbal communication to interact one with the other (Delaney and Madigan, 2015). Society is based on human interaction. Society and its subparts are continuously created and recreated as the persons interact with each other. Meaningfully, social reality is a constant flow of events requiring the involvement of multiple persons and actors (Stryker and Vryan, 2006). This approach not only focuses on the social interactions among and between the social actors, but also holds the idea that individuals assign their own perceptions and meanings to situate the external world surrounding them (Benzies, and Allen, 2001).

The theoretical framework of this analysis intends to explain the impact and pervasiveness of the FIFA World Cup 2022 in Bangladesh in line with the three major sociological perspectives: functionalism, conflict theory and symbolic interactionism. Each perspective uniquely influences society, social forces and human behaviours. Thereby, the impact and connectedness of the greatest show on the earth in the context of Bangladesh may be explained by these theories.

MATERIALS AND METHODS

This article is framed on content analysis. News, events and activities related to the FIFA World Cup 2022 and Bangladesh captured in various online English news portals were analysed in line with the essence of the three major sociological perspectives. Since no empirical work has so far been conducted on the FIFA World Cup 2022 Bangladesh, news portals were the only available sources of information. Data that indicated having a clear interface between Bangladesh and the FIFA World Cup 2022 were included only. Available data were then carefully assessed, narrated and included to display the best fitting under a particular theoretical perspective. During analysis, data were finally corroborated by the relevant empirical literature availed through google scholar and Scopus databases. As being a review, no formal ethical approval was needed. It is admissible that a single source can never produce an exhaustive or accomplished set of data to explain a grand social phenomenon like the World Cup.

ANALYSIS

FIFA World Cup, Bangladesh and functionalism

According to functionalism each component of the society is interrelated and contributes to the smooth operation of the society. The following scripts related to the FIFA World Cup 2022 seem to have a strong functional embodiment in Bangladesh society.

Bangladesh was intrinsically associated with the Qatar World Cup in many important ways. Bangladeshi migrant workers in Qatar made a phenomenal contribution to the construction of mega infrastructural projects required for hosting the tournament. According to a recent estimate, more than 400,000 Bangladeshi migrants work in Qatar (Delwar, 2022). But Qatar specifically recruited approximately 2,80,000 semi-skilled and less-skilled workers during the last few years of the world cup (GoB, *nd*). The number of migrant workers increased due to the rise of construction projects in Qatar. Bangladeshi expatriates brought a positive socio-economic contribution to Bangladesh by sending remittances. Such a contribution helped to minimise the internal labour market pressure and keep the balance of payment at ease. Importantly, remittances sent from Qatar aided to commissioning Bangladesh from a low-income country to the status of a middle-income country (Delwar, 2022).

The apparel sector also opened up some economic opportunities for Bangladesh. This sector produced 600,000 official t-shirts for the World Cup in Qatar. The worth of these garments is roughly around 160 million Taka. Apparels worn at such an esteemed international occasion demonstrate Bangladesh's highest ability in this sector (Mazumder, 2022; Kalerkantho, 2022). It may also stand as a good landmark for future foreign investment/business in this sector.

Football fans in Bangladesh traditionally support two Latin American rival camps: Argentina and Brazil. But this world cup has scenically brought the relationship between Bangladesh and the champion team Argentina to a new level; from deep admiration and love for football to rebuilding of bilateral relationship at the state level. During the world cup, Argentineans became overwhelmed and mesmerised by the way Bangladeshis extended their support to their team. Immediately before the World Cup semi-finals the Argentine foreign minister twitted that Argentina would reopen its diplomatic mission in Bangladesh which has been closed since 1978 (Saim, 2022). After winning the World Cup, Bangladesh's Prime Minister warmly congratulated Argentina and expressed hope to further consolidate the relations by opening embassies in each other's countries (Bhattacherjee, 2022). Argentina reopened its diplomatic mission in Bangladesh in soonest possible time on 27 February 2023. The two countries signed several bilateral agreements including one football cooperation (Sumon, 2023). This new bilateral move of cooperation will immensely benefit Bangladesh in matters of tourism, trade relations, investment, cultural exchange and so on (Saim, 2022). During the financial year 2021-22, Bangladesh exported 9.5 million dollars' worth of goods to Argentina. On the contrary, Argentina exported 791 million dollars' worth of goods to Bangladesh without having any diplomatic relations. The trade relations between the two countries will surely jump up in the coming years (Uddin, 2023).

Meanwhile, the local sports goods market also escalated during the FIFA World Cup. Bangladesh Sports Goods Merchants, Manufacturers and Importers Association had estimated to have a business of Taka 10000 million on this occasion. Local manufacturers in Bangladesh made around 5 million jerseys and 5 million flags of different countries participating in the World Cup. Since the local producers were unable to meet the full demands of the supporters, traders had to import a large number of sports items from abroad. After jerseys, football was the most demanding product. Souvenirs like key rings, wristbands and so on were also sold in ample (Azad, 2022a). Items were sold from street shops to large shopping malls in the country. The World Cup period was a good source of income for many businessmen in Bangladesh.

Despite several positive effects, the country witnessed a few incidents of social dysfunctions during the World Cup such as chaos, fan violence, extreme brutality and hooliganism. Of course, the most rivalries took place between Brazilian and Argentinian fans.

At least seven people were injured in *Khustia* district in a clash between supporters of Argentina and Brazil. Two of them were admitted to the hospital in critical condition and the rest five received primary treatment. Locals gathered to watch the final match on a big screen. Brazil fans were supporting France in the final match. The moment Argentina won the match and its fans started celebrations, the clash began (Sobuj, 2022). In another incident outside the capital city, around three hundred supporters of Argentina and Brazil were involved in a huge clash with rocks and bricks at each other. The clash began on matters of the actual strength of the two teams. Several supporters were injured very badly (Prothom Alo, 2022). Attacks and vandalization of the houses of the supporters of one team by the supporters of another team were also common during the World Cup (The Daily Star, 2022a). More destructively, since the beginning of the World Cup, at least five supporters have been killed in different areas of the country during fan fights between Argentina and Brazil (Sarkar, 2022).

FIFA World Cup, Bangladesh and conflict theory

Conflict theory focuses on how conflict arises in large social structures. The FIFA World Cup provides evidence of Marxist class conflicts and class relations in the context of Bangladesh.

Bangladeshi migrant workers became prey to capitalist class oppression in Qatar. Qatar's World Cup infrastructures were built by migrant workers. There have been ongoing debates, claims and accusations against Qatar regarding migrant workers' rights. A report published by the *Guardian* in 2021 claimed at least 6,751 migrant workers died in Qatar from five South Asian countries such as; Bangladesh, India, Nepal, Pakistan and Sri Lanka. At least 1,018 of them were Bangladeshi workers. While Amnesty International alleged that 15,021 migrant workers died in Qatar between 2010 and 2019 during the construction of the FIFA World Cup infrastructures (Walter and Ford, 2022; Dhaka Tribune, 2022a).

On behalf of Nadim Sharaful Alam, an exploited Bangladeshi migrant worker, a lawsuit was filed in 2016 with a Swiss court against FIFA to force Qatar to ensure fundamental human and labour rights of migrant construction workers and to bring in adequate and effective labour reforms including the right to quit a job or leave the country. Two Bangladeshi workers' groups namely, the Bangladesh Free Trade Union Congress (BFTUC) and the Bangladesh Building and Wood Workers Federation (BBWWF) joined in this lawsuit against FIFA, alongside the Dutch Trade Union Federation (FNV) (The Guardian, 2016; Arabian Business, 2016). Later on, the court rejected this case against FIFA as it observed that parts of the complaint such as introducing new labour laws and courts in Qatar were too vague or not legal (DW, 2017).

But ground evidence in Qatar portrayed disturbing pictures in terms of workers' rights and privileges. For example, a report published by the Business and Human Rights Resource Centre in April 2022 confirmed between 2016 and 2022 at least 24,400 migrant workers, mostly hired from Bangladesh, Nepal and India, were abused in incidents associated with the FIFA World Cup 2022 construction works. Most of these abuses include non-payment of wages, health and safety violations and resultant injuries and deaths, hazardous working conditions, control of freedom of expression and freedom of movement (Ahamad, 2022). Amnesty International, in another report, categorically highlighted the existence of multiple forms of abuses and widespread violations of labour rights. It further called for FIFA's responsibilities and Qatar's obligations under international human rights laws and standards to prevent widespread human and labour rights violations and provide sufficient remedies for victims of abuses (Amnesty International, 2022). To cite a shocking example, less than four weeks before the start of the football tournament Qatar forcibly evicted thousands of foreign workers including Bangladeshis from several buildings located mostly in neighbourhoods where the government rented buildings for the World Cup fan accommodation. Such a *'deliberate ghetto-isolation'* move captured critical international attention regarding Qatar's maltreatment of foreign workers and its social laws.

Ironically, international workers who had built infrastructures to host the World Cup were being alienated ahead of the appropriate time for celebration (Dhaka Tribune, 2022b).

Back home in Bangladesh, mentioning the deaths, injuries and inhuman treatment of Bangladeshi migrant workers in Qatar between 2010 and 2022, a writ petition was lodged in the High Court of Bangladesh in January 2023. The good point is that the Court issued a rule asking the concerned Bangladeshi authorities to prepare a list including the names of migrant workers who were involved in construction works of the FIFA World Cup and to explain why they should not be directed to give adequate compensation to the families of migrant workers (The Daily Star, 2023).

Workers in the ready-made garment factories in Bangladesh also poured much sweat and tears on the eve of the tournament. The garment industry in Bangladesh produced jerseys and T-shirts for FIFA and domestic markets. In return, it broadly helped the capitalist factory owners. The garment sector is notoriously noted for exploitation of the workers in terms of cheap wages, poor and unsafe working conditions (Foyez, 2022).

FIFA World Cup, Bangladesh and symbolic interactionism

Symbolic interactionism is used to analyse human interactions by focusing on the meanings that individuals assign to things and events surrounding them. The FIFA World Cup 2022 brings many examples from the perspective of symbolic interactionism in Bangladesh.

Although Bangladesh is in no way a great football playing nation, this country is always floated by the World Cup football euphoria. Bangladeshi fans take insane measures to show their love and devotion for their beloved teams. While there are fans of European teams, most Bangladeshis get divided into two South American teams: Brazil and Argentina (Bakul and Siam, 2016). During the World Cup football fever grasps each and every corner of Bangladesh, from the capital city to remote areas. Even a person who has little knowledge about football also gets affected by this fever (Kamal and Jashim, 2022). Looking at the collective hype amongst Bangladeshi, it is hard to explain how a country gets so passionate about football which virtually has any chance in the near future to participate in this grandest tournament (Saikat, 2022). Symbols and other means of communication played an important role in supporting respective teams during the World Cup 2022. Colourful flags, fancy jerseys, mascots, chants, songs and yells all created a high wave across the country. Different TV channels and online platforms telecasted live matches and arranged programmes with experts. Supporters gathered to watch the matches on giant TV screens in several spots of the country. The tournament regularly got the lead space in the newspapers. Musicians released new songs on this occasion. Social media platforms were very active and several fan groups were also formed. Refereeing to the collective emotion of the supporters in Bangladesh, FIFA once tweeted, *"Nothing brings people together like football"* (Daily Bangladesh, 2022a). Argentina team tweeted, "*Thank you Bangladesh, your support was wonderful*" (The Daily Star, 2022b). Bangladesh's supports and love for football attracted attention of the rest of the world (Ali, 2022).

A few days before kicking off the tournament, football lovers in the hill town of *Rangamati* painted three mountain bridges with the colours of the Argentina and Brazil flags. Two of them were painted in Argentinian colour while the other one in Brazilian colour. Thereafter, a cold war began between the supporters of the two sides centring on the bridges (Dhar, 2022; Hoque, 2022).

Masudur Rahman, a big fan of the Argentinian team who used to live in Qatar for ten years returned to Bangladesh a month before the World Cup. Then he initiated to share the joy of the World Cup with his fellow

villagers in *Faridpur* district by making eight replica stadiums of Qatar World Cup 2022 on a local field. He wanted to give villagers a feeling that they are watching the match sitting inside the stadiums in Qatar. He also arranged to show the matches on a big screen and hoisted the flags of the 32 participating. Accommodations and food were available for the spectators visiting from other areas. He also organised a ceremony on the opening day of the World Cup. For all these actions, he had to spend half a million Bangladeshi Taka (Hasan, 2022; Hoque, 2022).

Abu Kausar Mintu, a resident of *Brahmanbaria* district had a crazy support demonstration for South Korea. He made a gigantic 4 kilometres long South Korean flag, costing him more than half a million Bangladeshi Taka. Besides personal savings, he even had to sell land property to meet the cost of this enormous flag-making (Hoque, 2022). In the same vein, a group of Argentina fans prepared a 3,000-foot-long flag in *Mymensingh* district. The flag was made with 1,500 yards of cloth in six days costing them 50,000 thousand Bangladeshi Taka. In addition to hoisting the flag they also purchased projectors, screens, and DTH to broadcast the football matches for the spectators (Hoque, 2022; Mahmood, 2022).

A supporter of Brazil in *Sirajganj* district painted his entire house with the colours of Brazil's flag and named it Brazil *bari* (home) (The Financial Express, 2022). There were several similar examples from different areas of the country. A vigorous local sports organiser Advocate Mahbubul Alam from *Brahmanbaria* district painted one of his buildings in Argentinian colours upon the request of his son. But as his daughters are supporters of Brazil, he was planning to paint his other building modelled after the Brazilian flag (Daily Bangladesh, 2022b). While a group of youths in the *Swamigagh* area of the capital city made a different initiative ahead of the tournament by painting graffiti of renowned football stars on a large wall (bdnews24.com, 2022).

Apart from several activities related to football euphoria as mentioned above, sometimes sad stories were also written during the World Cup. In these cases, individuals' interactions with football were so volatile that they could not keep going with the normal flow of the tournament.

Upen Chandra Mondal, a devoted supporter of Argentina from *Barishal* district died after suffering a heart attack while watching the semi-final match between Argentina and Croatia. He had suffered the attack out of over-excitement immediately after Argentina scored the first goal (Swapan, 2022). Kawser Javed, another Argentinian supporter from *Cumilla* district also died of a heart attack while watching his team conceded a 1-2 defeat against Saudi Arabia (New Age, 2022). Sadly, one report confirmed that at least six teens (aged between 13 and 19) died while hoisting flags of their favourite teams from critical positions. In all cases, they were either fans of Brazil or Argentina. They died due to electrocution and falling from a height (Azad, 2022b).

DISCUSSION

FIFA World Cup is a glorious global event. Unquestionably, the biggest show on earth. Every four years this fiesta brings in a great impact on people, societies and cultures around the world. Its social, cultural, economic and political implications for the globe are unprecedented. Bangladesh always feels a great tremor by the World Cup. The influence of the World Cup in Bangladesh has not been researched before. Sociology is a pertinent disciple to explore the fabric of interconnectedness between Bangladesh and the World Cup. As evidenced from the above, the three major theoretical perspectives in sociology can shed light on the impact of the FIFA World Cup 2022 in Bangladesh in some significant ways.

Functionalism seems to be a very relevant theory to the study of sport (Delaney, 2015). Functionalism takes note of the nature, function, values and moralities of sport as a social institution and the connection sport

maintains with other institutions of a given society (Snyder and Spreitzer, 1974). Sport as a social institution provides both manifest/intended and latent/unintended functions. Even certain aspects of sports may be also dysfunctional or disorderly to some people (Delaney and Madigan, 2015). Billions of people find ways and means to organise their lives around some events of sport. Often it is hard to find which aspects of society are not affected by it (Shultz et al, 2015). The findings under functionalism suggest that the FIFA World Cup 2022 had some beneficial consequences for Bangladesh. Evidently, the tournament was economically beneficial to Bangladesh due to remittances sent by the expatriate workers from Qatar. Bangladesh also earned a lot by exporting sports items to Qatar. Many traders within the country also found the World Cup period as a good source of income. It may be noted that countries in today's world develop bilateral relationships with each other keeping in mind mutual economic benefits. After rejuvenating the bilateral relationship with Argentina, economic opportunities will open up for Bangladesh in manifolds. The economy always plays a pivotal role in stabilising the social system and maintaining its equilibrium. Economic exchange among rational individuals/parties has a potential function for a society by having gains from trade and business (Jackson, 2002). Of course, there were examples of dysfunctions or deviant behaviours such as murder or killing by fans of the opponent team during the World Cup. Despite sport promoting many important and desirable social functions, it also spurs deviant behaviours including some of the worst, aggressive, intimidating and gravest kinds of activities (Dziubinski, 2009; Delaney and Madigan, 2015). In particular, football hooliganism is a global and persistent problem spanning over several decades and football madness leading to violence is steadily increasing (Newson, 2017). Notably, Bangladesh maintains a bad record in football-related dysfunctions. For example, during the glorious period of club football in Bangladesh, fan conflict, hooliganism and damage to property were very rampant and intrusive (Bandyopadhyay, 2016).

Bangladesh's attachment to the World Cup may also be explained by the conflict theory. Conflict theorists/Marxist sociologists view sport as integral to society and a significant element of global capitalist society (McDonald, 2015). Conflict theory is mostly concerned with the implication of power, domination and exploitation in diverse aspects of sport (Delaney and Madigan, 2015). They consider the rise of sport from a materialistic perspective (Delaney and Madigan, 2015). For them, modern sport is seemingly a product of capitalism which emerged in eighteenth-century as part of the growing commercial entertainment industry (Collins, 2013). Sport stands as a critical analytical source within the capitalist class relationships and exploitations (McDonald, 2015). For example, ever since Qatar won the bid to host the 2022 World Cup, the government had poured billions of dollars into infrastructural development. Such development was exclusively contingent upon international migrant workers. Over a period of time, there was constant international scrutiny on Qatar about migrant labour/human rights abuses including dangerous labour conditions, lack of workers' rights, low wages, dilapidated living conditions and so on. In particular, the country's migrant sponsorship system (called *kafala*) was grossly criticised as it grants companies and employers to exploit migrant workers through an oppressive legal bondage system. Often it creates a grievous power imbalance between the employees/sponsors and workers (Babar and Vora, 2022). Not to mention, poor considerations of labour/human rights issues are not new to capitalism and imperialism. Furthermore, evidence suggests that holding mega-events such as the FIFA World Cup have always resulted in economic growth and development in manifolds for the host country (Al-Dosari, 2020; Al-Emadi, 2022). While Qatar gained opportunities to stimulate its capital growth by hosting the World Cup, some concerns will always remain unanswered regarding its labour/human rights interventions and the ways the key contributors (migrant workers of different countries including Bangladesh) were alienated from the key process and product of the means of production, 'the FIFA World Cup'.

Sport is closely shaped by symbolic interaction with its social contacts and communications (Djalal, 2015). The ways fans in Bangladesh showed attachment during the FIFA World Cup 2022 to their respective teams

and favourite players provide unique examples of symbolic interactionism. Their emotional involvement attests to the assumption as if they were members of that particular football team or country. According to Herbert Mead, an individual's personality development is contingent upon his membership in a particular group (Djalal, 2015). At least for the period of this mega tournament, the devoted fans and supporters of the respective teams had distinct personality make-up expressed through language, bodily embodiments and non-verbal communications. Further to state, football always stands as a phenomenal source of social interaction-the essence of symbolic interactionism (Djalal, 2015). Fans and participants maintain close interactions and cohesions with sporting actions and processes (Delaney and Madigan, 2015). Symbolic interactionism highlights the meaning, identity formation, social relationships and subcultures within events of sports (Crossan, 2012). Individuals are sometimes fans or members of sports groups/clubs, sometimes they play particular sporting roles or perform in sports events and sometimes they are spectators of different types (Weiss, 2001). Fans and supporters are emotionally associated with the physical construction of the players. The outfits, achievements, fitness and social power of the players have an alluring impact on the fans to support a particular team (Berry, 2010). Specific to the dramaturgical aspect of symbolic interaction, the FIFA World Cup always stands as a special social stage that evokes a remarkable emotional performance from fans and supporters. Bangladeshi fans and supporters were great actors on the stage and performed according to the script. Dramaturgical metaphors such as "*staged*," "*actors*" and "*scripted*" (Zurcher, 1982) were not artificial, false or irrelevant to Bangladesh. The emotions and performances of Bangladeshis during the World Cup were very realistic and socially adorable.

CONCLUSION

This analysis captures the sociological significance of the FIFA World Cup 2022 in the context of Bangladesh. The sociological significance of this versatile event is immense. During the World Cup 2022 football fever in Bangladesh was injected into the masses so intensely that it was almost impossible for someone to keep aside from it. The three major sociological perspectives such as functionalism, conflict theory and symbolic interactionism offer important insights into the FIFA World Cup 2022. Functionalism illustrates that the World Cup had brought some visible beneficial consequences for Bangladesh although some evidence of violent destructions due to fan factionalism was also noted. According to the conflict perspective, this event had a major impact on Bangladeshi expatriate workers involved in infrastructural projects. The issues related to the breach of labour rights affected the workers in serious ways. Notably, the international spotlight on labour rights issues for a host country was more visible this time than ever before. Finally, symbolic interactionism exerted a strong presence in the everyday behaviour and life pattern of Bangladeshi fans, supporters and general people during the World Cup. The intense association of people in Bangladesh with this event asserts the fact that football has important meanings in their life.

This is the maiden study using the major sociological perspectives to explore the interface between Bangladesh society and the FIFA World Cup 2022. From here, researchers may avail some directions to use sociology to further explain the implications of this mega event. Several emerging perspectives in sociology such as post-structuralism, post-modernism, feminism or critical race theory may be good sources for further analysis. Scholarly interventions using field-based empirical evidence are also strongly suggested.

Considering the impact, involvement, mass-following or even consequences of the FIFA World Cup 2022 in Bangladesh, the nation should strive to improve its football-playing status at the international/professional level. In particular, the nature and extent of fan following should be used as a good booster for the development of football in Bangladesh.

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