

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

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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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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.

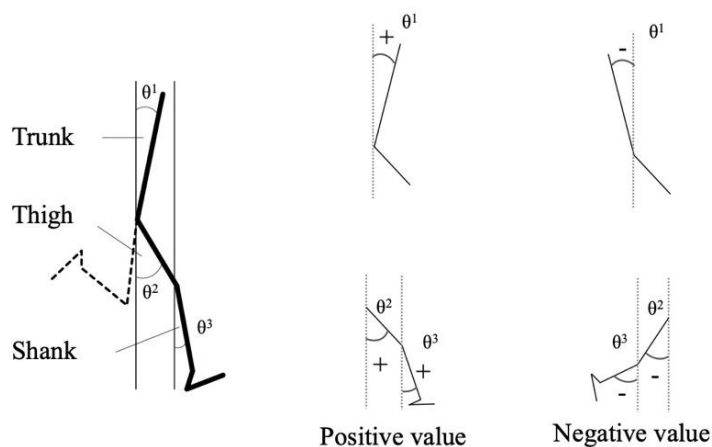
No.	Training contents (Concepts)	Target movement to be modified
1	Walking and running with upright posture (Understanding the front-side mechanics)	Excessive forward tilt of the trunk
2	Rebound jump (Ankle stiffness and avoiding the heel strike)	Excessive forward swing of the shank
3	Dribble (knee lift)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

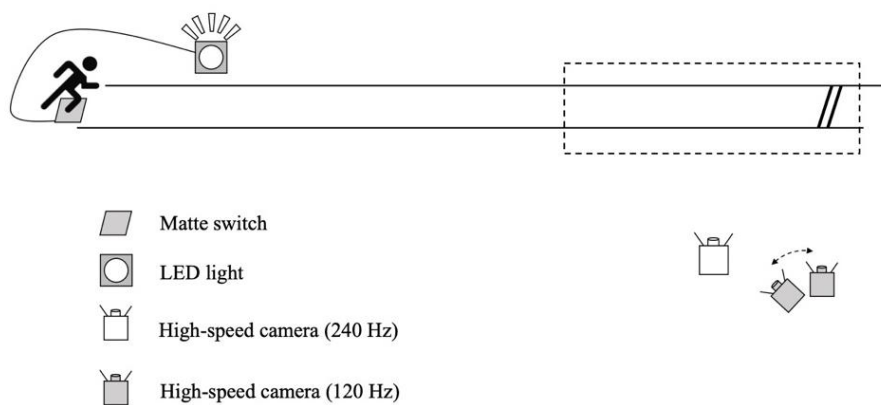


Figure 2. Definition of the trunk and lower limb movements.

Statistical analysis

All variables are presented as mean \pm 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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