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ORIGINAL ARTICLE

Drop jump characteristics of basketball players based on the multi contact time jump test

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ABSTRACT

In this study, we examined the drop jump characteristics of 27 male college basketball players using the multi-contact time jump test. The participants jumped off a 30-cm platform, and the time until their landing on the floor randomly varied from approximately 0.1 to 1.0 s in 0.1-s increments. Their jumping time was measured, and the jumping height was calculated. In this study, the countermovement time during the trial in which the maximum jumping height was achieved was defined as the optimum value of the countermovement time for the individual. Therefore, the participants' optimal countermovement time was distributed from 0.4 to 1.1 s, and the mode was 0.7–0.8 s. The rebound drop jump index increased with decreasing optimal countermovement times. Cluster analysis of the relationship between the optimal countermovement time and jumping height showed that the patterns were classified into three patterns (Patterns 1–3). There was a significant difference in the optimal countermovement time for each pattern ($p < .01$). However, there was no significant difference in the maximum jumping heights among the patterns.
Keywords: Performance analysis, Basketball player, Multi contact time jump test, Drop jump characteristics, Optimal countermovement time.

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INTRODUCTION

Human runners and jumpers execute running and jumping by first producing a stretch contraction in the primary muscles of the lower limbs and then switching to a shortening contraction. This type of exercise is called the stretch–shortening cycle (SSC) exercise (Norman and Komi, 1979). Zushi et al. (1993) compared the characteristics of lower-limb muscular strength and power in athletes of 14 sports, including short-distance races, jumping, ski jumping, rugby, and track and field events using the rebound drop jump index (RDJ-index), an index calculated by dividing the jump height by the ground contact time, vertical jump height, and isometric maximum muscle strength by squatting posture. They showed that short-distance and jumping athletes had an extremely high RDJ-index compared with athletes specializing in other events.

Tauchi et al. (2002) showed a significant positive correlation between personal records and the RDJ-index in javelin throwers and that of athletes in throwing events. In addition, there are other methods to evaluate the performance of SSC exercises, such as the single-leg rebound jump (Kariyama et al., 2012, 2013) and rebound long jump with horizontal movement (Fujibayashi et al., 2013). Furthermore, the RDJ-index and rebound jump index can assess the ability to perform ballistic SSC movements (Zushi et al., 1993). However, this evaluation method has its limitations.

Takamatsu (2017) pointed out that it is difficult to determine the characteristics of various sports disciplines and individuals using only the RDJ-index when considering the characteristics of various sports. Kigoshi (2016) also pointed out that when an athlete is instructed to jump high with the shortest possible ground contact time, an overemphasis on shortening the ground contact time may sacrifice the jumping height.

However, Kajitani et al. (2018) developed a new jump test that can be used to examine the length and shortness of ground contact time without sacrificing the jumping height. The multi-contact time (MCT) jump test (Kajitani et al., 2017) is a test that can measure jumps, from ballistic jumps in which the ankle joint is the main moving joint to vertical jumps in which the hip joint is the main contributor, depending on the length of the countermovement time (ground contact time). Cluster analysis was conducted using the maximum jumping height and optimal countermovement time in the MCT-jump test as indices. Therefore, five types were successfully identified, suggesting that the MCT-jump test is a valid method for assessing the drop jump characteristics of athletes (Kajitani et al., 2018). Ogata and Kigoshi (2020) also reported that the optimal countermovement time in the MCT-jump test varied depending on the content of training and physical conditioning and may be associated with performance in competition depending on the individual. Ishikawa (2020) also showed that drop jump characteristics differ depending on the specific type of track and field event.

Therefore, athletes with high performance in SSC exercises are suited to competitions and positions requiring considerable jumping and footwork with short ground contact times. The MCT-jump test is used to evaluate such athletes.

Furthermore, basketball is a five-on-five game in which the players put the ball in the ring for four quarters of 10 min. Players not only run but also jump and make repeated and intense physical contact. Among other things, in jumping movements such as rebounding, a player may jump only once to pick up a dropped shot or jump repeatedly if he cannot get it the first time. Miura et al. (2010) studied the relationship between jump height and contact time during layup shots in basketball. The results showed no significant correlation between jump height and ground contact time. There was an independent relationship between layup shooting and rebound jumps with one or both feet and ground contact time on rebound jumps with one foot.

Therefore, understanding the drop jump characteristics is essential when considering basketball training. Consequently, in this study, we aimed to examine the drop jump characteristics of college basketball players using the MCT-jump test.

METHODS

Participants

The participants were 27 male athletes from the University of H's basketball team. Their average age, height, weight, and years of competition were 20.4 ± 1.1 years, 176.3 ± 5.4 cm, 72.8 ± 6.9 kg, and 5.4 ± 2.3 years, respectively. The positions reported by the participants were guard (G), forward (F), and center (C). Twelve participants played G, 12 played F, and 3 played C. The participants were fully informed about the purpose, methods, and risks of the study, and their consent to participate in the measurements was obtained.

Measurement procedure

The MCT-jump test (Kajitani et al., 2018) was performed as follows. After warming up, participants were asked to jump down from a 30-cm-high platform and then up again. During the test, the participants kept their hands on their heads to avoid upper limb counter movements.

The participants were instructed to get off the platform, touch the floor, and jump up at a randomly assigned time ranging from approximately 0.1 to 1.0 s. The jumping time in each trial was measured, and the jumping height was calculated. Immediately before each test, the participants were asked to listen to an electronic sound of standard length. They were instructed to jump high with a reaction time corresponding to the length of the electronic sound.

The participants were instructed to jump as high as possible in all trials. They were also instructed to jump "*shorter*" or "*longer*," as necessary. Notably, some participants were unable to perform the test with the shortest reaction time (<0.15 s); therefore, we instructed them to perform the test with a reaction time of <0.24 s (which was classified as 0.2 s) and to make the reaction time as short as possible.

All the trials were performed using a force plate (Kistler 9281B, 9281E, Winterthur, Switzerland). The software (TRIAS, Q'sfix, Tokyo, Japan) was used to calculate the ground contact time (s) and dwell time (s), and the jump height (m) was calculated from the dwell time of each trial using Equation (1) (Asmussen and Bonde-Petersen, 1974).

$$H = 1/8 \cdot g \cdot t^2 \quad (1)$$

where H is the jumping height, g is the gravitational acceleration (9.81 m/s^2), and t is the jumping time.

The RDJ-index was calculated by dividing the jumping height by the ground contact time (Zushi et al., 1993), and the index was the highest value obtained. The countermovement time of the trial with the highest jump height was defined as the optimal countermovement time.

To identify the optimum countermovement time, an approximate curve was drawn for the relationship between the countermovement time and jumping height when the same maximum jumping height was confirmed at several countermovement operation times. The value that was closer to that line was selected as the optimum countermovement time.

Statistical analysis

The values for each measure are presented as mean ± standard deviation. IBM SPSS Statistics ver. 29 (IBM Corp., Armonk, NY, USA) was used for the statistical analysis. Cluster analysis was used to classify participants into different types based on the optimal counter-movement time and maximum jumping height. Differences between the patterns of cluster analysis were subjected to a one-factor analysis of variance, and Bonferroni's multiple comparisons were performed when a significant F value was obtained. Statistical significance was set at $p < .05$.

RESULTS

Figure 1 shows the frequency distribution of the participants' optimal recoil time. The participants' optimal countermovement time ranged from 0.4 to 1.1 s., with a mode of 0.7–0.8 s.

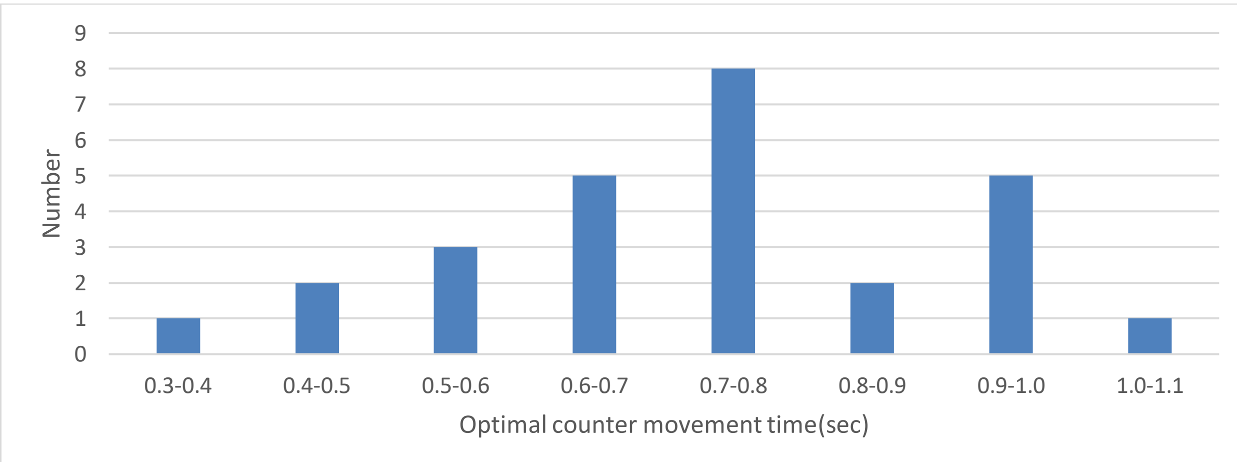

Figure 1. Histogram of optimal countermovement time.

Figure 2 shows the relationship between optimal countermovement time and RDJ-index, where RDJ-index = –0.9755 ground contact time + 1.2586 (r = 0.918). The RDJ-index increased with decreasing optimal countermovement times.

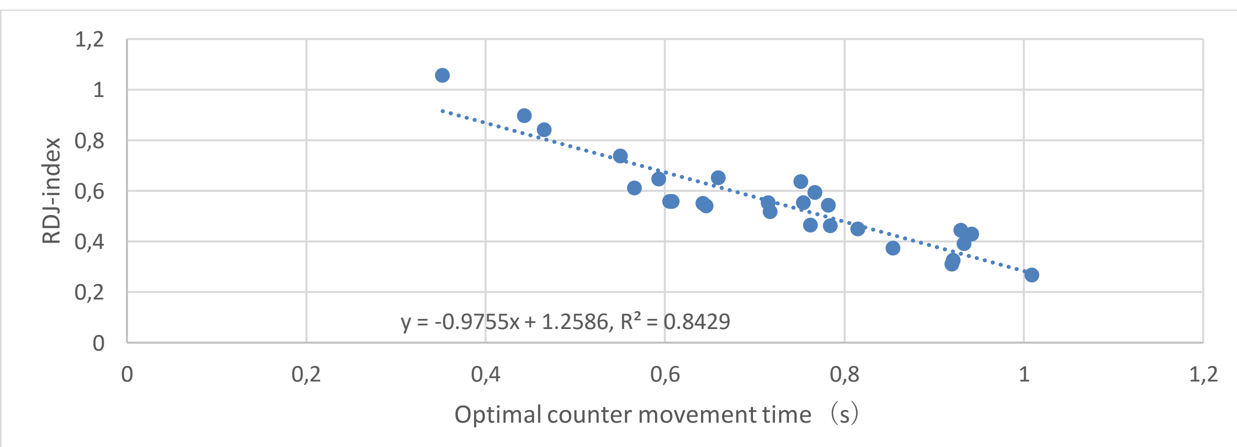

Figure 2 Relationship between optimal countermovement time and rebound drop jump index (RDJ-index).

Cluster analysis of the relationship between optimal countermovement time and jumping height revealed three patterns: Patterns 1 (n = 3), 2 (n = 7), and 3 (n = 17) with a shorter, medium, and longer optimal countermovement time, respectively.

Figure 3 shows the relationship between each pattern's optimal countermovement time and jumping height. There was a significant difference among the three patterns regarding optimal countermovement time ([F2, 24] = 37.548, $p < .001$). Significant differences were found between Patterns 1 (0.420 ± 0.060), 2 (0.601 ± 0.036), and 3 (0.824 ± 0.101) for the optimal countermovement time ($p < .01$, respectively). However, there was no significant difference in maximum jumping height between the patterns (Pattern 1: 0.387 ± 0.013 m; Pattern 2:0.359 ± 0.025 m; and Pattern 3: 0.378 ± 0.059 m).

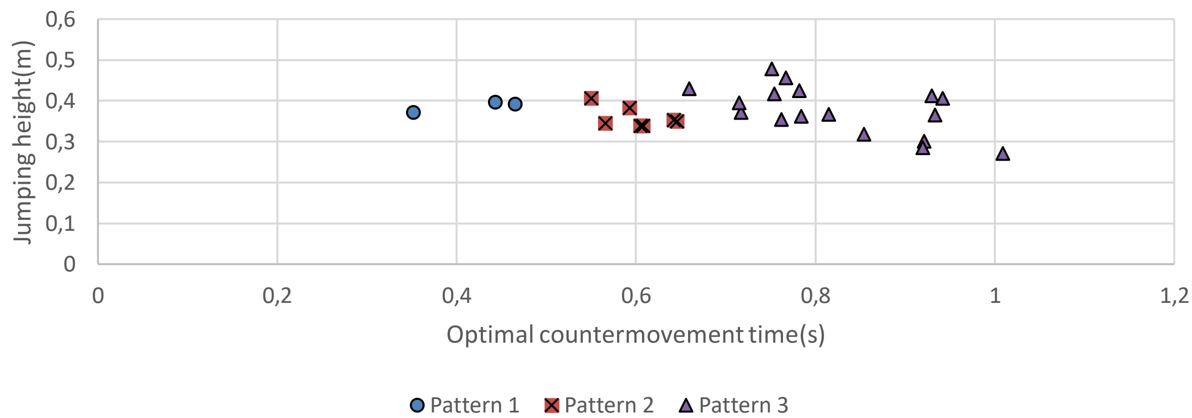

Figure 3 Relationship between optimal countermovement time and jumping height based on cluster analysis.

Table 1 shows the number of participants according to the pattern and position. Three of the 12 participants in G had Pattern 1 (25%), two had Pattern 2 (16.7%), and the remaining seven had Pattern 3 (58.3%). Five of the 12 participants in F had Pattern 2 (41.7%), and seven had Pattern 3 (58.3%). In C, all three participants had Pattern 3 (100%).

Table 1. Number of people based on pattern and position.

	Guard	Forward	Center	Total
Pattern1	3	0	0	3
Pattern 2	2	5	0	7
Pattern 3	7	7	3	17
Total	12	12	3	27

DISCUSSION AND CONCLUSIONS

In this study, we aimed to examine the drop jump characteristics of college basketball players using the MCT-jump test. The results showed that the optimal countermovement time for basketball players was 0.72 ± 0.16 s, and the maximum jump height was 0.37 ± 0.05 m. These values were slightly higher than those reported by Ishikawa (2020) for track and field athletes (0.77 ± 0.19 s, n = 47) and track and field athletes in short and short (0.81 ± 0.09 s, n = 10), jumping (0.80 ± 0.19 s, n = 7), short and long (0.83 ± 0.11 s, n = 10), medium distance (0.86 ± 0.11 s, n = 7) and slower than long-distance (0.61 ± 0.27 s, n = 10).

Zushi et al. (1993) divided athletes into three groups based on indices that evaluate their ability to execute drop jumps, vertical jump height, and isometric maximal muscle strength in a squatting posture. Group A had the highest drop-jump performance index, followed by vertical jump height and isometric maximal muscle strength in squatting posture, and vice versa for group B. Group C was classified as a group that did not belong to either group A or B. Group A included track and field jumpers, short-distance athletes, gymnasts, and kendo athletes, whereas Group B included ski jumpers, skaters, and swimmers. Group C comprised ball-sport athletes (basketball, handball, baseball, badminton, soccer, and rugby) and long-distance track and field athletes. As described above, ball sport athletes were difficult to classify by their jumping ability alone because they were required to have complex abilities that were not limited to running and jumping. Furthermore, many athletes who play competitive sports, such as basketball, have few drops jump characteristics.

In this study, we conducted a cluster analysis based on the optimal countermovement time and maximum jumping height. Participants were classified into three patterns. Pattern 1 corresponded to the hard muscles that achieved maximum jumping height with shorter optimal countermovement time. In contrast, Pattern 3 corresponded to the soft muscles that achieved the maximum jumping height with a relatively longer optimal reaction time, and Pattern 2 corresponded to those between Patterns 1 and 3. As described previously, most basketball players in this study had soft muscles, and only a few had relatively short or intermediate optimal countermovement times.

Based on their positions, participants who showed Pattern 1 in G and F tended to play more games than those who showed Patterns 2 or 3. Therefore, in ball games like basketball, height is advantageous in terms of physical characteristics. In addition, taller players have the advantage of possessing various abilities. Notably, basketball is a sport that requires composite and integrated abilities, not just a single ability. The results of this study suggest that if other abilities are equal, basketball players might have an advantage of having a shorter optimal countermovement time as a drop jump characteristic.

Notably, Ishikawa (2020) found five clusters, whereas this study found three. In athletics, daily practices tend to be subdivided according to the needs of each sport. However, practice time in basketball tends to be spent developing tactical and team skills rather than improving individual physical skills. Basic skills are addressed individually. This is particularly true for college basketball. Therefore, the main focus of daily practice may not necessarily be to improve an individual's physical abilities.

Furthermore, regarding drop jump characteristics, male and female volleyball players have reported that the rebound jump index (both feet, left foot, and right foot) tended to be higher for setters than for attackers and receivers (Aruga et al., 2012, 2013). Therefore, jumping ability characteristics according to the position were observed in volleyball. In basketball, players rarely perform different types of movements for each position, and they perform the same movements even if they change positions. In addition, basketball players in positions G, F, and C jump for rebounding, jump shots, shot checking (including shot blocking), layup shots, and power plays (Koyama et al., 2012). No relationship was found between jumping ability and position; however, those who jump faster and higher may be superior because they perform the same action at the same height.

Application to practice

The results of this study showed that the participants' optimal countermovement time ranged from 0.7 to 0.8 s at the highest frequency. Notably, most participants were in Pattern 3, which had the longest optimal countermovement time, followed by Pattern 2, which was in the middle, and Pattern 1, which had the shortest optimal countermovement time. Pattern 1, with a shorter optimal countermovement time, has a higher RDJ-index, which is considered advantageous in basketball games, with Pattern 1 > Pattern 2 > Pattern 3. In particular, the ability to compete in rebounding and other jumping actions, such as jumping only once to pick up a dropped shot or jumping repeatedly if the shot is not taken the first time, is also necessary. Therefore, physical training for each position should include jump training based on drop jump characteristics.

AUTHOR CONTRIBUTIONS

Conceptualization: T. Aoki and T. Ueda. Data curation: T. Aoki., S. Ishikawa Formal analysis: T. Aoki, S. Hashimoto and T. Ueda. Investigation: T. Aoki., S. Ishikawa and S. Hashimoto Methodology: T. Aoki and T. Ueda. Project administration: T. Ueda. Resources: T. Ueda. Supervision: T. Ueda. Validation: T. Ueda. Visualization: T. Ueda. Writing –original draft: T. Aoki. Writing –review & editing: T. Ueda.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

We communicated the intent and methods of this study to the subjects. We also obtained informed consent. This research was also approved by the research ethics committee of the Graduate School of Education, Hiroshima University. The committee gave a reference number HR-ES-001679.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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