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The Relationship Between Simple Isometric Mid-Thigh Pull and Jumping Abilities: A Case Series Study

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ABSTRACT

Isometric mid-thigh pull (IMTP) is used to measure and monitor the peak force and the rate of force development. However, current IMTP implementation is costly and time-consuming. Thus, a quick, low-cost, and easy method is needed to monitor muscle strength. This case series study aimed to examine the relationship between IMTP assessed using a back strength dynamometer and jumping abilities and determine whether relative strength (N/body weight [BW]) can indicate jumping abilities. Eleven female collegiate basketball players in division III female Tokai Student Basketball League participated in this study. A back strength dynamometer was used to measure IMTP. The starting posture was a 145° relative angle at the knee and hip joints with the chain extended. Jumping measurements were performed for squat jump (SJ), countermovement jump (CMJ), and rebound jump (RJ) using a jump mat.

Additionally, the highest rebound jump index (RJI), jump height, and ground contact time for the highest RJI were used in the statistical analysis. Participants were divided into high (HG) and low (LG) groups based on the median value of relative strength. Cohen's *d* as an effect size (ES) with a 90% confidence interval was used to compare the jumping abilities between the groups. The relationship between relative strength and jumping abilities was determined using Pearson's correlation coefficient. The HG showed significantly moderate ES for SJ height (d=1.19) and RJ height (d=1.19), and significantly larger ES for RJI (d=1.36) relative to those of the LG. In addition, no significant correlations were observed between relative strength and any of the jump measures. However, relative strength exhibited a moderate correlation coefficient for the correlation between RJI and ground contact time. Therefore, IMTP assessed using a back strength dynamometer can be used to monitor muscle variables related to jumping abilities at a lower cost and training time than those of conventional methods.

Keywords: isometric mid-thigh pull, isometric strength, jumping ability

INTRODUCTION

Many studies have reported the relationships between the absolute or relative peak force (PF) of the isometric mid-thigh pull (IMTP) and dynamic performance (1, 2, 8, 10, 11). For example, Comfort et al. (2) reported moderate to strong correlations between the absolute PF of IMTP and squat jump (SJ) height, countermovement jump (CMJ) height, sprint times, and 505 change of direction time. In addition, Beattie et al. (1) reported that the absolute PF and the relative PF of IMTP are moderately correlated with the reactive strength index (RSI) and jumping height of a drop jump (DJ). Furthermore, athletes who had a strong absolute PF and relative PF of IMTP had significantly higher RSI and height in the DJ than those of weaker athletes, with moderate to large effect sizes (ES) (1). Based on these studies, we believe that the absolute PF and relative PF of

IMTP can be used to monitor the muscle strength required for jumping abilities.

Monitoring muscle strength capacity is essential for athletes. The one-repetition maximum (1RM) test is a popular measurement of muscle strength capacity in practice and is highly reliable (5). However, the 1RM test is unsuitable for regularly monitoring muscle strength capacity during competitive seasons because of its injury risk and time-consuming nature. In contrast, IMTP has low injury risk and physical stress because it involves static movement and finishes quickly (2). Additionally, it can be performed by many individuals because the exercise technique is simple. Therefore, the IMTP is a suitable regular monitoring method during competitive seasons. However, implementation of the IMTP requires costly force plates, specialty racks, software, and measurement time that creates barriers to implementing routine measurements for large populations. Therefore, a quick, low-cost, and simple method of measuring IMTP to monitor muscle strength is needed.

This case series study aimed to determine whether relative strength weight (N/body weight[BW]) can indicate jumping abilities and examine the relationship between IMTP assessed using a back strength dynamometer and jumping abilities. We postulate that relative strength can indicate jumping abilities, and the correlation coefficients for the correlation between relative strength and jumping abilities are similar to those in previous studies.

METHODS

Participants

The participants were 11 female collegiate basketball athletes in the division III female Tokai Student Basketball League (age, 19.4±0.8 years; height, 162.8±5.0 cm; weight, 61.3±11.0 kg) (Table 1). Informed consent for the publication of the data was obtained from the athletes after the measurement because a part of the fitness tests used in this study were conducted during team practices. This case series study was approved by the Research Ethics Committee of Aichi Toho University (No. 202208).

IMTP measurement

A back strength dynamometer (Back–D, Takei Scientific Instruments Co. Ltd, Niigata, Japan) was used to measure IMTP. The starting posture was a 145° relative angle at the knee and hip joints with the chain extended (4) (Figure 1). The participants were instructed to pull the chain as fast as possible with maximum effort for 5 sec. Two trials were performed with a minimum rest period of 2 minutes between trials. The result was expressed in kilograms. Therefore, the value in Newton was calculated as kilogram × 9.81. The highest relative strength was used for statistical analysis.

Jumping measurements

Jumping measurements were performed for SJ, CMJ, and rebound jump (RJ) using a jump mat (S-CADE Corp., Tokyo, Japan). All jumps were performed twice with the hands on the hips. Each jump measurement was performed twice, with the rest period between the trials being 30 sec.

Table 1. All participant's data and normality

Variables	Mean ± SD	95% confidence interval	*p*-value for normality
Age (years)	19.4 ± 0.8	18.8 - 19.9	–
Height (cm)	162.8 ± 5.0	159.5 - 166.2	–
Body weight (kg)	61.3 ± 11.0	53.9 - 68.7	–
IMTP / BW (N / kg)	14.2 ± 2.3	12.7 - 15.8	0.777
Squat jump height (cm)	27.8 ± 3.3	25.6 - 30.1	0.708
Countermovement jump height (cm)	29.4 ± 3.2	27.3 - 31.5	0.761
Rebound jump index (m / s)	1.64 ± 0.41	1.36 - 1.91	0.048*
Rebound jump height (cm)	27.6 ± 5.3	24.1 - 31.2	0.286
Rebound jump contact time (sec)	0.171 ± 0.015	0.161 - 0.181	0.295

*$p<0.05$

Figure 1. Posture of isometric mid-thigh pull

SJ was performed by flexing the knee joint to 90°, determined using a clipboard, and holding it for 2 sec. The participants then jumped as high as possible without any countermovement. For the CMJ, the participants jumped from a standing position using countermovement, while RJ consisted of one trial with five consecutive jumps. For the RJ, the participants were instructed to perform high jumps with short ground contact times. The rest period between the modality of jumping measurements was a minimum 2min. The highest jump height for SJ and CMJ, the highest rebound jump index (RJI = rebound jump height/contact time), and the jump height and ground contact time for the highest RJI were used in the statistical analysis.

Statistical analysis

All data were presented as mean ± standard deviation with a 95% confidence interval (CI). The median relative strength ratio was used to divide the participants into high (HG) and low (LG) groups. Cohen's *d* as an ES and 95% CI for ES were used to compare the jumping abilities between the groups. The magnitude of ES was defined as: almost none, <0.2; small, 0.2–0.6; medium, 0.6–1.2; large, 1.2–2.0; and very large, 2.0–4.0 (6). If the 90% CI of the ES did not exceed 0, a significant difference was considered to be present. In addition, normality was evaluated using the Shapiro–Wilk test. If normality was rejected, a log-transformation was performed. The relationship between relative strength and jumping abilities was determined using Pearson's correlation coefficient. The correlation coefficients were determined as follows: small, ±0.1–±0.3; medium, ±0.3–±0.5; large, ±0.5–±0.7; very large, ±0.7–±0.9; and almost perfect, ±0.9–±1.0 (6). The significance level was set at $P < 0.05$. Statistical analyses were performed using the EZR software

Table 2. The effect size and 90% confidence interval (CI)

Variables	LG (mean ± SD)	HG (mean ± SD)	ES (*d*)	90%CI for ES	Magnitude of ES
IMTP/BW (N/kg)	12.4 ± 1.3	16.1 ± 1.7	2.49*	1.03 - 3.94	Very large
SJ height (cm)	26.1 ± 3.8	29.8 ± 2.1	1.19*	0.04 - 2.33	Moderate
CMJ height (cm)	27.8 ± 3.3	31.0 ± 2.7	1.08	-0.05 - 2.20	Moderate
RJI (m/s)	1.45 ± 0.11	1.91 ± 0.47	1.36*	0.18 - 2.53	Large
RJ height (cm)	25.5 ± 3.0	30.9 ± 5.7	1.19*	0.04 - 2.33	Moderate
RJ contact time (sec)	0.176 ± 0.011	0.164 ± 0.017	0.83	-0.26 - 1.92	Moderate

**Significant difference*

LG = low group, HG = high group, ES = effect size, IMTP = isometric mid-thigh pull, BW = body weight, SJ = Squat jump, CMJ = Countermovement jump,

RJI = rebound jump index, RJ = rebound jump

(Saitama Medical Center, Jichi Medical University, Saitama, Japan).

RESULTS

The HG showed a significantly moderate ES for SJ height (*d*=1.19), CMJ height (*d*=1.08), RJ height (*d*=1.19), and ground contact time (*d*=0.83) and significantly larger ES for RJI (*d*=1.36) than those of the LG (Table 2). In addition, normality was rejected for the RJI. Therefore, we performed log-transformation for the correlation analysis on the relationship between relative strength and RJI. No significant correlations were found between relative strength and any of the jump measures. The correlation coefficients for the correlations between relative strength and the jump measures were not significant for SJ height (r = 0.222, p = 0.511), CMJ height (r = 0.169, p = 0.619), RJI (r = 0.354, p = 0.285), RJ height (r = 0.263, p = 0.434), and ground contact time (r = -0.411, p = 0.209).

DISCUSSION

Based on our results, participants with higher relative strength had higher jumping abilities than those with lower relative strength. Although the RJI and ground contact time showed moderate correlation coefficients (r = ±0.3–±0.5), they were insignificant. ES ± 90% CI was used to examine whether the relative strength could indicate jumping abilities. The HG showed significantly moderate ES in SJ compared with the LG. A previous study reported the relationships between one-repetition maximum and SJ and CMJ heights (3, 16). In addition, the absolute PF and relative PF of IMTP have been reported to be significantly related to SJ and CMJ heights (2, 8, 10, 11). Our results suggest that a person's muscular strength influences SJ and CMJ performance as the mechanisms of concentric power and slow stretch-shortening cycle (SSC) (7) benefit from strengthening programs. Similarly, previous studies have reported that strength training improves SJ and CMJ height (9, 13, 15). Therefore, muscular strength is essential for improving jumping performance, and a back strength dynamometer may be used to evaluate muscular strength regularly.

Further, the RJI showed a significantly larger ES in the HG than in the LG. In addition, a significantly moderate ES was found for RJ height in the HG compared to those in the LG. Furthermore, the differences were greater in jumping height (21.1%) than in ground contact time (6.8%) between the groups, which was similar to that reported by Beattie et al. (1). A fast SSC is influenced by faster sports performance with a ground contact time of < 250 ms (for example, sprint running and drop jumping) because of stored elastic energy in tendons (14). In addition, a fast SSC is affected by the function of the muscle-tendon complex. Sugisaki et al. (12) reported that the muscle-tendon complex extension in the lower leg of an RJ is primarily due to a tendon tissue with only a small fascicle extension. This allows the tendon to store and utilize elastic energy. Therefore, isometric strength is essential for a fast SSC because of stored elastic energy in extended tendons.

This case series study observed no significant relationship between the relative strength ratio and each jump. However, a moderate correlation coefficient was observed for the RJI, which was similar to that reported by Beattie et al. (1). They used DJ as a measure, while the present study used RJ. A DJ is performed by jumping down from a box, which differs from an RJ's movement mode. However, both jumps require a fast SSC with a ground contact time of <250 ms (14). Thus, we believe that similar correlation coefficients were observed because both jumps were performed using a fast SSC.

Furthermore, variables related to RJ showed a moderate correlation coefficient, which may be related to the specificity of the joint angle. Lum et al. (8) reported that the correlation between isometric exercise and dynamic performance is stronger when the joint angles are similar. In this case series study, the IMTP posture had a relative angle of 145° at both the knee and hip joints. The SJ and CMJ are performed with a knee joint angle of approximately 90°. Conversely, the posture used in an RJ was similar to that of an IMTP in our study because it was performed with slight flexions of the knee and hip joints. Therefore, a moderate correlation coefficient was observed for an RJ. Due to the small sample size, there were no significant correlation coefficients for variables related to RJs.

This case series study had several limitations. First, the sample size was small, and only female collegiate athletes were assessed. As a result, the training condition, content, and sex may have influenced the relationship between relative strength and jumping abilities. Furthermore, this study's participants had a strength and conditioning experience of 6 months–3 years. However, strength and conditioning experience did not influence participant categorization into HG and LG. Second, the participant's grip strength may have affected the IMTP measurement because the IMTP measurements were not taken with weightlifting straps. Finally, this was a cross-sectional study. Therefore, further research is needed to determine how these results change with the effects of training.

CONCLUSION

Participants with higher relative strength had higher jumping abilities than those in the lower relative strength group. Therefore, the relative strength could be used to indicate jumping abilities. Analyzing data from IMTP testing that uses force plates is costly and time-consuming. However, we believe the strength and conditioning coach should regularly monitor the effect of training on the changes in muscle variables related to jumping abilities throughout the season comprehensively. Thus, IMTP assessed using a back strength dynamometer can monitor muscle variables related to jumping abilities at a lower cost and training time than conventional methods.

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