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Investigation of The Relationship Between Dynamic and Reactive Strength Variables in Wrestlers

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Abstract

In order to achieve a positive improvement in an athlete's performance, what to do in the next training phase is possible by accurately monitoring the changes made by the previous training phases on performance. The aim of this research is to determine the relationship between dynamic and reactive strength variables for accurately determine the strength requirements of wrestlers. 24 male wrestlers participated in the research voluntarily. The suitability of the data for normal distribution was evaluated with the Shapiro-Wilk test. Kruskall-Wallis H test was used to determine the difference between data groups. Regression analysis was applied to estimate RSI values at different heights of DSI values obtained from the research group. According to correlation analysis; It was determined that the RSI value obtained from the 50 cm jump height showed the highest correlation with other heights. The Kruskall Wallis H test, RSI values obtained from different jump heights do not show a statistically significant difference compared to DSI index criteria ($p>.05$). The regression analysis, it was revealed that there was a moderate and significant relationship between RSI values at different heights and DSI value ($R=0.516$, $R^2=0.466$, $p>0.05$). It can be said that the application of RSI values at higher jump heights in wrestlers increases the correlation coefficient with the DSI values, and the 70 cm jump height is determinant in revealing the explosive force.

Keywords: Dynamic strength index, Reactive strength index, Wrestling,

Introduction

In order to achieve a positive improvement in an athlete's performance, what to do in the next training phase is possible by accurately monitoring the changes made by the previous training phases on performance (Comfort, Thomas, Dos'Santos, Suchomel, et al., 2018; DeWeese et al., 2015).

In order for the wrestler to be successful during the competition, his physiological, physical and motoric abilities should come to the fore as well as his technical and tactical characteristics (Kraemer et al., 2004). Wrestling includes advanced capacities for strength, speed, flexibility, coordination, quickness, agility, balance, aerobic capacity and maximal anaerobic power abilities of athletes consisting of short-term and high-intensity movements that include open skills (Chaabene et al., 2017; Horswill, 1992; Yoon, 2002). It is known that wrestling develops in direct proportion to strength development (Lansky, 1999). Especially strength and maximal power abilities play an important role in the performance processes of wrestlers (Yoon, 2002). Therefore, the majority of wrestling training consists of exercises aimed at developing maximal strength and power.

It is known that wrestlers do general strength training during the preparation period within a training period. However, athletes need different strength requirements (maximal strength, explosive strength, continuity in strength) (Horswill, 1992). In order to meet the strength requirements effectively, the strength parameters of the athlete must be known.

In this context, the aim of the research is to determine the relationship between dynamic and reactive strength variables in order to accurately determine the strength requirements of wrestlers.

Material and Method

Ethics committee permission

Licensed athletes in wrestling clubs operating in Ankara participated in the research voluntarily. Participants signed the voluntary consent form before the research. Ethical permission for this research was discussed by Gazi University Ethics Commission at the meeting numbered 10 dated 24.05.2022 and approved with code number 2022-688.

Participants

The research group consisted of wrestlers training in Ulaştırma, Yaşar Dogu Wrestling Specialization, Champion Wrestlers and Ankara Metropolitan Municipality Sports Clubs operating in Ankara.

The descriptive statistical results of the height, body weight and body mass index values obtained from the wrestlers (n=24) who make up the research group are given in Table 1.

Table 1. Descriptive statistics results from wrestlers

Variables	Mean	SD
Age (years)	19.75	3.3
Height (cm)	175.63	5.99
Weight (kg)	79.29	15.57
Body Fat Percentage (%)	14.36	5.93

Sports Age (years)	6.79	3.81
Weekly Training Hour (Hours)	13.71	4.89
Body Mass Index (kg/m^2)	25.59	3.91

Abbreviations: BFP= Body Fat Percentage, SA= Sports Age, WTH= Weekly Training Hour, BMI= Body Mass Index, SD= Standard Deviations

Data Tools and Collection

Height measurement

The heights of the athletes were measured with a Seca (22089 Hamburg, Germany, Model:213 1721009 35/13, Designed in Germany- Made in Chine) height meter with an accuracy of ±1mm.

The wrestlers, barefoot and wearing standard athletic attire (shorts and t-shirts), were positioned in the anatomical stance with their heels and back aligned against the vertical metal rod of the stadiometer. Stature was measured in centimeters and systematically recorded from the device's calibrated scale.

Body weight and body fat percent measurements

Body weight (BW) and body fat percentage (BFP) of the athletes were assessed using a Tanita BC-418 MA segmental body composition analyzer (Maeno-cho, Itabashi-ku, Tokyo, Japan). To ensure measurement accuracy, athletes were instructed to refrain from eating or consuming any liquids (including water, coffee, alcohol, etc.) for at least three hours prior to testing, to avoid any form of physical activity on the day before the test, and to abstain from using saunas or bathing. Additionally, they were informed in advance regarding toilet usage protocols both the day before and on the day of the assessment. All measurements were conducted with participants wearing light athletic clothing (shorts and t-shirts).

Prior to the measurement, a 0.5 kg tare was applied to the Tanita device to account for clothing weight. Participants' age and height were entered into the system. Subjects were then instructed to step onto the metal footpads barefoot, after which the device measured their body weight. During the impedance assessment, participants held the hand electrodes with both hands, arms fully extended, parallel to the torso, and approximately five centimeters away from the body, ensuring no flexion at the elbows until the measurement was completed. Upon completion, the device automatically printed the BFP (%) and BW (kg) values.

Isometric mid-thigh pull (IMTP) (maximal strength)

The Baseline Back Strength Dynamometer (T.K.K.5402, Back-D, Takei Scientific Instruments Co., Ltd., Japan) was utilized to assess the maximal isometric strength of the lower extremity musculature. (Beattie et al., 2017; Stone et al., 2005).

Participants were instructed to report for testing wearing standardized athletic attire, including shorts, t-shirts, and training shoes. Prior to testing, a structured warm-up protocol was administered, consisting of five minutes of low-intensity jogging followed by two minutes of dynamic stretching exercises. During the test, participants were positioned with their feet placed on the designated foot markers on the dynamometer platform. They were instructed to flex their knees to an angle of 131° ± 9°, maintain fully extended elbows, and keep their spine in a neutral alignment, ensuring that the head, thoracic, and lumbar regions remained upright and stable throughout the measurement. (Beattie et al., 2017). The dynamometer's chain was individually adjusted so that the handle aligned with the mid-thigh level, positioned just above the participant's patella.

In order for the participants to get used to the test and to warm up, 50% and 75% of the perceived difficulty level were each pulled. A one-minute rest interval was given between trials. Following the completion of the warm-up and familiarization trials, three maximal strength measurements were recorded from each participant. Each athlete was given a 2 minute rest period between measurements. After removing the gap in the chain of the dynamometer during each measurement, the athletes were asked to push the dynamometer strongly with their feet and to pull the rod of the dynamometer as fast and hard as possible. Athletes were asked to pull the rod of the dynamometer for five seconds. The test was started with the command "3, 2, 1 check" (Comfort, Thomas, Dos'Santos, Jones, et al., 2018). Verbal statements were directed to the athletes to motivate them while pulling. The last data indicated by the needle of the dynamometer was recorded in kg.

Reactive strength index measurement

The reactive strength index (RSI) of the athletes was measured using the Opto Jump Next system (Bolzano, Bozen, Italy) (Beattie et al., 2017; Healy et al., 2016; Lehnert et al., 2018).

The Drop Jump protocol was performed using the Opto Jump Next®□ system to assess the reactive strength index (RSI). Prior to the test, participants received verbal instructions regarding the procedure, followed by a two-minute warm-up specifically designed for jumping exercises. Leaps of getting used to the test were made. After resting for two minutes, they were asked to stand on the wooden box with a height of 30, 40, 50, 60 cm, with 30 seconds of rest between the tests, respectively (Beattie et al., 2017; Beattie & Flanagan, 2015; Flanagan & Comyns, 2008; Markwick et al., 2015; Prieske et al., 2019; Walsh et al., 2004; Young, 1995). The wrestlers were asked to extend one foot forward, with their hands on the waist, to fall into the $1m^2$ interior of the device, which is parallel to each other on the floor, and to jump as high as they can quickly as soon as they touch the ground (Walsh et al., 2004). Athletes were instructed to avoid knee flexion during the jump and to perform the test while maintaining muscular tension throughout. The test was repeated twice, with a 30-second rest interval between attempts, and both ground contact time and jump height were recorded. The reactive strength index (RSI) was calculated based on the highest RSI value (m/s) obtained, using the following formula: RSI = Jump height (m) / Ground contact time (sec). (Beattie et al., 2017; Flanagan & Comyns, 2008).

Vertical jump measurement

The vertical jump performance of the athletes was assessed using the Opto Jump Next system (Bolzano, Bozen, Italy).

Countermovement jump was made to determine the vertical jump height of the athletes (Comfort, Thomas, Dos'Santos, Suchomel, et al., 2018). Active jump protocol is applied in Opto Jump Next® device. Before the test, the participants were given verbal information about the measurement. Practice jumps were performed three times. A two-minute rest period was given, and then it was tested. A 150 cm long, 0.5 kg, 3 cm diameter wooden stick was used to prevent the participants from pulling their shoulders and arms. Participants took the wooden stick on their shoulders and made three jumps. They held the wooden stick on their shoulders throughout the jump. Leap results were recorded in cm.

Dynamic strength index measurement

Comparing the peak force achieved during CMJ and IMTP by calculating the dynamic strength index (DSI=CMJ PF/IMTP PF) has been proposed to provide information about the training requirements of athletes. DSI = Ballistic peak force / Isometric peak force ratio was calculated with the help of formulas (Comfort, Thomas, Dos'Santos, Jones, et al., 2018; Suchomel et al., 2020).

DSI values detected in athletes were evaluated according to Table 2 (Cormie et al., 2011; Suchomel et al., 2020).

Table 2. Percentages used in the interpretation of DSI

DSI Score	Overall Assessment	Recommended Training Program
<%60	Low	Ballistic Strength Training
%60 - %80	Moderate	Concurrent Strength Training
>%80	High	Maximal Strength Training

Statistical Analysis

Statistical analysis of the data was performed using IBM SPSS Statistics Version 21 (IBM Corp., Released 2012, Armonk, NY). The normality of the data was assessed using the Shapiro-Wilk test. The Kruskal-Wallis H test was employed to determine differences between groups for data that did not follow a normal distribution. Regression analysis was conducted to predict BMI values based on the reactive strength index (RSI) values at different jump heights within the study group. A significance level of $p < 0.05$ was considered statistically significant.

Findings

Statistical analyzes of the dynamic strength obtained from the wrestlers constituting the research group and the reactive strength index values obtained from different heights are given in this section.

Regression analysis results of wrestlers reactive strength index values at different angles to predict their DSI values (7.58±21.22) are given in Table 3.

Table 3. Regression analysis results regarding the prediction of DSI values of reactive strength index values of wrestlers at different heights

Variables	B	SD	β	T	p	Part r	Partial r
Constant	100.335	16.840		5.958	0.000**		
40 cm RSI m/s (1.15± 0.34)	-45.679	22.967	-0.745	-1.989	0.061	-0.236	-0.415
50 cm RSI m/s (1.22± 0.35)	-10.526	33.133	-0.178	-0.318	0.754	-0.106	-0.073
60 cm RSI m/s (1.21± 0.35)	-37.830	47.542	-0.635	-0.796	0.436	0.089	-0.180
70 cm RSI m/s (1.10± 0.38)	76.594	36.572	1.404	2.094	0.042	0.270	0.533
$F_{(4-19)}$=1.720	P=0.028						

R=0.516	R^2=0.466

*p ≤ 0.05, **p ≤ 0.001

Upon examining Table 3, a moderate and statistically significant relationship is observed between the RSI values at different jump heights and the DSI value. (R=0.516, R^2=0.466, p>0.05). The aforementioned variables together give 47% of the total variance in the DSI value. According to the standardized regression coefficient (β), it is seen that the RSI value revealed at 70 cm jump height has a significant effect on DSI, while RSI predictive variables at other heights do not have a significant effect on DSI. When the bilateral and partial correlations between predictive variables and DSI jump were examined, a moderate and positive relationship was found between 70 cm jump height RSI and DSI, and negative and low correlations with other RSI values.

The correlation results for the relationship between the reactive strength index (RSI) values at various jump heights are detailed in Table 4.

Table 4. Correlation results of the relationship between the reactive strength index values revealed at different heights

Variables		**40 cm RSI m/s**	**50 cm RSI m/s**	**60 cm RSI m/s**	**70 cm RSI m/s**
40 cm RSI m/s	Pearson Correlation	1	0.803	0.836	0.843
	P		0.000**	0.000**	0.000**
50 cm RSI m/s	Pearson Correlation	0.803	1	0.936	0.931
	P	0.000**		0.000**	0.000**
60 cm RSI m/s	Pearson Correlation	0.836	0.936	1	0.952
	P	0.000**	0.000**		0.000**
70 cm RSI m/s	Pearson Correlation	0.843	0.931	0.952	1
	P	0.000**	0.000**	0.000**	

*p ≤ 0.05, **p ≤ 0.001

Upon examining Table 4, it was found that the RSI value obtained from the 50 cm jump height exhibited the strongest correlation with the RSI values at other jump heights in the correlation analysis. In other words, 50 cm jump height is considered as an important height in revealing the RSI.

The Kruskall Wallis H-test results regarding the difference in the RSI values of the wrestlers at different heights according to the ballistic, concurrent and maximal strength criteria obtained from the DSI test are given in Table 5.

Table 5. H-test results regarding the difference of RSI values of wrestlers at different heights according to ballistic, concurrent and maximal strength criteria obtained from DSI test

Variables		**Mean**	**SD**	**X^2**	**P**
40 cm RSI m/s	Ballistic	1.19	0.26	0.621	0.733

	Concurrent	1.13	0.41		
	Maximal	1.15	0.40		
50 cm RSI m/s	Ballistic	1.28	0.34	1.750	0.417
	Concurrent	1.12	0.39		
	Maximal	1.26	0.37		
60 cm RSI m/s	Ballistic	1.25	0.38	1.369	0.504
	Concurrent	1.13	0.33		
	Maximal	1.26	0.39		
70 cm RSI m/s	Ballistic	1.07	0.39	0.992	0.609
	Concurrent	1.04	0.38		
	Maximal	1.21	0.43		

*$p \leq 0.05$, **$p \leq 0.001$

Upon examining Table 5, the RSI values obtained from different jump heights do not exhibit a statistically significant difference according to the DSI index criteria ($p > 0.05$). In other words, it was determined that wrestlers with different criteria according to the DSI value had similar RSI values in their jump heights. It can be said that the RSI values of the wrestlers who need ballistic strength training at 40 and 50 cm heights, and the wrestlers who need maximal strength at 60 and 70 cm jump heights, are better.

Discussion and Conclusion

According to the existing literature, studies in which RSI and DSI values are measured together are very few. The aim of this study is to examine the differences and the relationship between DSI and RSI values in wrestlers. The commonly used reactive strength index measures the ability of athletes to switch to concentric contraction (stretching-shortening cycle) abruptly after eccentric muscle contraction (Newton & Dugan, 2002; Young, 1995). Some studies have reported that the RSI is a valid performance measure that can discriminate between athletes at different competitive levels (James et al., 2020). At the same time, the optimal drop height values can be determined with the RSI measurement (Byrne et al., 2010). Optimal drop height values (respectively; 30cm, 20-40-50 cm, 40 cm) vary in many different sports branches such as athletics, basketball and volleyball (Andrade et al., 2017; Flanagan & Comyns, 2008; Markwick et al., 2015). In the literature, there is no reliable optimal jump height in accordance with the characteristics of the wrestling branch. According to the results of this study, 50 cm jump height is important in determining the RSI values in wrestling athletes.

Like RSI in DSI, it is very important to determine the ability of athletes to produce force in the shortest time. In DSI, on the other hand, it is aimed to determine the dynamic strength abilities of the athlete according to the maximum strength capacity. This index is very useful for determining whether the athlete needs maximum strength training, ballistic strength training or concurrent training as stimulant training. Since DSI measures the ability of athletes to generate force during a dynamic or isometric test and their ability to generate force during a ballistic exercise, conditioners can determine how much of this potential athletes can use during a high-intensity movement. Therefore, DSI is seen as a tool to evaluate an athlete's lower body strength qualities and to guide future training programs (Sheppard et al., 2011). Expressed as the ratio DSI = ballistic peak force (N) / isometric peak force (N) (Sheppard et al., 2011; Young et al., 2014). In the researches, two different methods, SJ and CMJ, were used to measure the ballistic peak force value in the dynamic strength index formula. The performance of an opposing/contra move is almost always reported to be better than a non-contra move in the absence of time pressure (McGuigan & Winchester, 2008; McGuigan et al., 2006). For example, height achieved or force produced during a CMJ is better than scores achieved during an SJ. The traditional view of the difference between CMJ and SJ performances is that the CMJ is a better test, as it reflects a better use of the stretch-shortening cycle. However, it should be noted that a larger difference is not always better (McGuigan et al., 2006). Although there is no significant difference between both methods, it has been proven that there is a strong relationship between these methods and DSI values (Comfort, Thomas, Dos’Santos, Jones, et al., 2018).

Studies of wrestlers have shown that isometric strength is compromised throughout a match (Kraemer et al., 2001). Some wrestlers can perform a lot of offensive action in short periods of time, while others can be more defensive and slow down the pace of the match (Kraemer et al., 2004). Because of all this, it is also necessary to measure the maximum force generation capacity to determine whether the athlete should emphasize explosive force production or maximal force production during the next training phase (Comfort, Thomas, Dos’Santos, Jones, et al., 2018). Therefore, in this study, while IMTP was used to determine the maximum isometric strength of the athletes, how much of the total strength capacity they could produce was determined with CMJ, which includes a ballistic movement.

According to the DSI values of this study, similar RSI results were seen in the 40-50-60-70 cm drop height of the wrestlers who need to do ballistic/concurrent or maximal strength training ($p > .05$). DSI ensures that wrestlers tend to appropriate training at different training stages during certain periods, but jump height is not related to the different training needs of the athletes.

RSI is important for standardizing drop jump height in depth jumps, but optimal drop jump height values are still under investigation due to methodological differences in studies. While investigating these values, the characteristics of the sports branch should be taken into account.

In conclusion, it can be inferred that the application of RSI values at higher jump heights, particularly the 70 cm jump height, plays a key role in revealing explosive strength, as it significantly enhances the correlation coefficient with DSI values. As a suggestion, the relationship between different long-term training programs and dynamic strength index can give more detailed information about the strength production of the athlete and his capacity to use it. RSI and DSI can allow wrestlers to train in accordance with their condition.

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