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Acute effects of different types of stretching exercises on explosive power: A pilot study

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Abstract

Athletes usually use warm-up and stretching exercises before starting a vigorous physical activity. The aim of this study was to investigate the positive and negative effects of different stretching and flexing exercises on kicking acceleration performance in taekwondo. A total of 12 elite taekwondo athletes (7 boys and 5 girls) with an average age of 20.75±1.48 years, an average height of 171±10.06 cm, an average body weight of 61.8±11 kg, and an average Body Mass Index (BMI) of 21.1±2.5 kg/m2 participated in this study. For the kick acceleration test (KAT), an accelerometer was used by attaching it to the ankle of the participants with the help of a smart phone and a smart watch. For KAT measurements, static stretching exercise (SSE), dynamic stretching exercise (DSE), proprioceptive neuromuscular facilitation exercise (PNFE) and ballistic stretching exercise (BSE) methods were applied on different days during the warm-up phase. In this study with elite level Taekwondo athletes, significant differences were found between palding chagi and dollyo-chagi kick acceleration values after SSE and PNFE applications ($p<0.05$). In addition, statistical analyses showed that DSE were associated with higher acceleration values than PNFE and BSE. As a result of the statistical analyses performed on KAT, it was observed that DSE method showed a significant difference between the measurements of torso level kicking and head level kicking parameters compared to other methods ($p<0.05$). Therefore, it can be concluded that DSE can be preferred to PNFE stretching and BSE when planning flexibility exercises in taekwondo training. According to the results of KAT, DSE did not have a significant negative effect in the training program, and it can be concluded that there is no obstacle to apply DSE in pre-competition warm-ups.

Introduction

In many sports, flexibility is one of the most important characteristics that athletes prioritize in terms of physical fitness (Nelson & Kokkonen, 2005). Athletes usually use warm-up and stretching exercises before starting a vigorous physical activity. Stretching exercises for a certain period of time after light physical activity are recommended for many sports branches (Bradley et al., 2007). More than one method is used to improve flexibility. Static stretching exercise (SSE) involves forcing the range of motion of a joint to remain in a fixed position for 15-60 seconds (Norris, 1999; Young & Behm, 2002), proprioceptive neuromuscular facilitation exercise (PNFE) method, which uses contraction and stretching together (Bradley et al., 2007; McBride et al., 2007), ballistic stretching exercise (BSE) method supported by rhythmic springs after stretching (Woolstenhultme et al., 2006) and dynamic stretching exercise (DSE) which consists of movements performed at a slow pace similar to the technique to be applied (Yamaguchi et al., 2008; Amiri-khorasani et al., 2010).

It is predicted that the performance of athletes will improve with increased flexibility. Also, it is thought that sports injuries will decrease with increased flexibility. According to these ideas, stretching exercises to increase flexibility are included in the training programs of athletes and coaches and in pre-competition warm-up exercises. Despite the acceptance and use of stretching exercises as one of the main components of pre-physical activity exercises, the alleged benefits of stretching exercises on performance parameters and sports injury prevention have been questioned in many review articles (Nelson & Kokkonen, 2005). For an optimal performance, the ability of athletes to stretch and lengthen their muscular structures is important, as well as the minimum

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resistance of the muscles to movement (Young, 2007). It is believed that these stretching and flexing exercises performed before the activity positively affect performance (Shellock & Prentice, 1985; Smith, 1994), reduce muscle tension (High et al., 1989) and most importantly, reduce the risk of sports injuries (Ekstrand et al., 1983; Garrett, 1990).

Considering all these views, various studies have been conducted to determine whether stretching and flexing exercises applied before activity affect some performance parameters. According to recent studies, acute static stretching has been shown to have negative effects on various maximum performance parameters (Fletcher & Anness, 2007; Maisettia et al., 2007; Cramer et al., 2007; McBride et al., 2007; Parsons et al., 2006). However, along with increased flexibility, the proposed benefits of SSE include injury reduction or prevention (Smith, 1994) and improved recovery and performance (Young & Behm, 2002; Young, 2007). In addition, BSE and DSE performed before the activity have been shown to have positive effects on performance tests such as jumping (Parsons et al., 2006; Woolstenhultme et al., 2006) and explosive force production. On the other hand, PNFE method, which is one of the flexibility types, has been observed to have an acute negative effect on some performances (Alemdaroğlu & Koz, 2009; Alemdaroğlu et al., 2012; Bradley et al., 2007; Cramer et al., 2007; McNeal & Sands, 2003).

Among the benefits of stretching and flexing exercises on sportive performance, it is known that they have a positive effect on the acceleration speed of athletes. Studies have shown that stretching exercises performed in training have a positive effect on the optimal acceleration performance of athletes. The ability to apply optimal force at maximum speed and subsequent effective acceleration can be achieved by increasing the stride length, i.e. the range of motion (ROM) of the lower extremities (Mann et al., 1984). Thanks to their improved performance, it is possible for athletes to exhibit different distance-time characteristics during higher force generation and acceleration phases. These characteristics show that the link between strength, flexibility, speed and acceleration is directly proportional (Cormie et al., 2010).

The aim of this study was to investigate the positive and negative effects of stretching and flexing exercises on kick acceleration in taekwondo. The study was designed considering that different stretching exercises would have a positive effect on kick acceleration performance in the training programs of taekwondo athletes and coaches. It is thought that the information obtained as a result of the study will help coaches to prepare training programs suitable for the branch and will contribute to future studies in this field.

Methods

Participants

Our research sample consists of elite taekwondo athletes over the age of 18 with at least black belt level, train at least 3 days a week and are national team athletes who are students at Manisa Celal Bayar University. The number of participants of our study was determined as 21, including 9 female athletes and 12 male athletes. In the literature, we see that the effect size of the number of participants is similar to our study, considering the experimental, acute studies and studies without a control group similar to our study (Bradley, 2007; Fletcher, 2007; Nelson, 2005).

Data Collection Tools

According to the study plan to be applied, the athletes were divided into two groups for body and head level kicks. Height measurements were made to adjust the height level of the two groups, one of which was body level kicking, and the other was head level kicking.

In the training program, for the kick acceleration test (KAT) measurements, it was planned to be performed for 4 days with static, dynamic, PNF and ballistic stretching methods to be applied on different days during the warm-up phase. In addition, it was planned that after the subjects taken for KAT jogged for 10 minutes, they would perform 5 minutes of stretching (static, dynamic, PNF, ballistic) specific to the day of the study and then switch to the kick acceleration test without a break.

Kick Acceleration Test (KAT)

In this test (Loturco et al., 2014), in which the taekwondo-specific rear-foot kick to body level technique (Palding-chagi) and the rear-foot kick to head level technique (Dollyo-chagi) were used (Loturco et al., 2014), the participant practiced the technique against a sandbag by strapping a smartwatch with an accelerometer (Watch series 9, Apple) to the ankle. During the technique, a smartphone application (Force Data, Balsalobre-Fernández, C.) was used to record positive acceleration data at a frequency of 200 per second and the maximum acceleration data was recorded for analysis. The unit of values measured with the accelerometer is meters/second^2. The force experienced during acceleration is called G-force (m/sec²/9.8= G). Therefore, the results obtained were converted into G-force units. The test was performed in two different ways according to the height of the participant's sandbag. First, 5 trials were taken at the trunk level and the highest score was recorded to be analyzed. Then the athletes were asked to apply the technique at the head level of their height, 5 trials were taken and the highest score was recorded for analysis.

In all the trials, the participant stood in the guard position with the toes of the feet not crossing the starting line. For the validity of the trial, compliance with taekwondo technical scoring criteria was sought. A 30 s rest was given between each application.

Data Evaluation

In the statistical analysis of this study, SPSS v23 software was used to determine the data obtained from the participants, descriptive characteristics of the participants (age, height, weight, BMI), arithmetic means and standard deviations (SD) of these characteristics. Friedman test was used to find the difference between different stretching exercises. Wilcoxon test was used to look at the difference between binary combinations. Nonparametric (Wilcoxon Test) analysis method was used because the number of participants included in the study was small and the participants were not normally distributed as a result of Shapiro Wilk normality test ($p<.05$). The significance level was determined as 5% ($p<0.05$).

Results

Descriptive statistics of the participants are presented in Table 1. The kick accelerations according to different flexibility methods in elite taekwondo athletes shown in Table 2.

There is a significant difference between the palding chagi kick acceleration values of taekwondo athletes after SSE and PNFE applications ($p<0.05$; Table3).

There is a significant difference between the Dollyo-Chagi kick acceleration values of taekwondo athletes after SSE-PNFE, SSE-BSE, DSE-PNFE and PNFE-BSE applications ($p<0.05$; Table 4).

Table 1

Descriptive characteristics of elite taekwondo athletes (Mean ± SD.

Variables	Elite Taekwondo Athletes (n=12)
Age (year)	20.75 ± 1.48
Height (cm)	171 ± 10.06
Weight (kg)	61.8 ± 11
BMI (kg/m^2)	21.1 ± 2.5

BMI: Body Mass Index.

Table 2. Mean values of different flexibility methods and kick acceleration of elite taekwondo athletes (Mean ± SD).

Flexibility Methods	Palding Chagi	Dollyo-Chagi
SSE	11.9 ± 1.40	13 ± 3.73
DSE	11.4 ± 1.96	11 ± 2.59
PNFE	10.3 ± 1.79	9 ± 2.32
BSE	10.8 ± 2.06	11 ± 2.12

SSE: Static Stretching Exercise; DSE: Dynamic Stretching Exercise; PNFE: Proprioceptive Neuromuscular Facilitation Exercise; BSE: Ballistic Stretching Exercise.

Table 3

The relationship between different flexibility methods and kick acceleration values of elite taekwondo athletes with palding chagi technique.

Flexibility Methods (Palding Chagi)		Mean Difference	Z	p
SSE	DSE	0.310	0.621	0.733
SSE	PNFE	1.495	2.257	0.012*
SSE	BSE	0.858	0.827	0.204
DSE	PNFE	1.102	1.328	0.092
DSE	BSE	0.530	0.908	0.182
PNFE	BSE	-0.349	0.556	0.289

*SSE: Static Stretching Exercise; DSE: Dynamic Stretching Exercise; PNFE: Proprioceptive Neuromuscular Facilitation Exercise; BSE: Ballistic Stretching Exercise; * p<0.05.*

Table 4
The relationship between dollyo-chagi technique and different flexibility methods and kick acceleration values of elite taekwondo athletes.

Flexibility Methods (Dollyo-Chagi)		Mean Difference	Z	p
SSE	DSE	2.095	0.521	0.301
SSE	PNFE	3.763	3.155	0.001*
SSE	BSE	2.480	2.257	0.012*
DSE	PNFE	1.615	2.457	0.007*
DSE	BSE	0.555	0.521	0.301
PNFE	BSE	-1.002	1.825	0.034*

*SSE: Static Stretching Exercise; DSE: Dynamic Stretching Exercise; PNFE: Proprioceptive Neuromuscular Facilitation Exercise; BSE: Ballistic Stretching Exercise; * p<0.05.*

Discussion

Assuming that DSE will improve KAT performance, this study was conducted to record the positive and negative effects of different stretching and flexibility exercises on sportive performance in taekwondo.

There are many studies investigating the effects of SSE, DSE, PNFE and BSE methods applied in the warm-up phase of training on the optimal performance of athletes (Bradley et al., 2007; Alemdaroğlu & Koz, 2009; Carvalho et al., 2009; Evans, 2006; Fletcher & Jones, 2004). At the same time, there are also studies on the relationship between different types of stretching methods and vertical jump tests that test explosive strength, one of the performance components of athletes. In one of these studies, Bradley et al. first suggested that SSE and PNFE stretching caused a decrease in vertical jump performance and that this decrease was related to changes in the stiffness of the muscle-tendon unit. BSE, another type of stretch, had minimal effect on jump performance. They stated that the reasons for this difference were the duration of stretching, stretching in muscle groups and the measurement methods used (Bradley et al., 2007).

In their study on the acute effects of different types of stretching exercises, Alemdaroğlu & Koz found that PNFE, SSE and BSE methods negatively affected both 10m and 20m sprint test performances, but the BSE method was less effective than the others after practicing sprint and change of direction (COD) skills. In addition, the return times of the performance values were examined in this study and it was determined that the performance returned to normal in 5 minutes after BSE, while the effect of static stretching lasted 15 minutes and the effect of PNFE stretching lasted 20 minutes (Alemdaroğlu & Koz, 2009). In another study, the effects of SSE on performance were evaluated by applying SSE to both legs for 30 seconds before and during a 20m sprint activity. The results showed that this method caused an increase of approximately 0.04sec in sprint time, i.e. a negative effect on performance (Nelson et al., 2005). Another study showed that 50m sprint performance was negatively affected after SSE (Fletcher & Anness, 2007). In a study investigating whether the "Illinois test", which measures the ability to change direction, is acutely affected by SSE, it was concluded that SSE did not have any negative effect on this performance characteristic (Kees, 2007). According to the results of a study examining the service speed of tennis players, it was found that static stretching did not affect the service speed (Knudson et al., 2004). It has been reported that static and PNFE stretching methods, especially when performed for a long time (fifteen seconds or more), reduce the sensitivity of the myotatic reflex and negatively affect strength. In BSE and DSE, on the contrary, it has been suggested that this effect does not occur, on the contrary, the muscle is prepared for movement (Alemdaroğlu et al., 2012).

In this study with elite level taekwondo athletes, significant differences were found between palding chagi kick acceleration values after SSE and PNFE applications (p=0.012, p<0.05). Furthermore, there is a significant difference between the dollyo-chagi kick acceleration values of taekwondo athletes after SSE-PNF, SSE-BSE, DSE-PNFE and PNFE-BSE (p=0.001, p=0.012, p=0.007, p=0.034 p<0.05). This suggests that DSE have the potential to increase the kicking velocity of taekwondo athletes. However, a comparison between PNFE and BSE showed that PNFE had a more positive effect on the acceleration values of palding chagi and dollyo-chagi kicks. These results suggest that PNFE can improve the flexibility and kick acceleration abilities of taekwondo athletes. When the significance levels are analyzed, it is seen that DSE have a more significant effect on the acceleration values of palding chagi and dollyo-chagi kicks than PNFE stretching and BSE (Table 2). Therefore, it can be concluded that DSE can be preferred to PNFE stretching and BSE when planning flexibility exercises in taekwondo training. As a result of the statistical analysis performed on KAT, it was observed that DSE method showed a significant difference between the measurements of the trunk level kicking and head level kicking parameters compared to the other methods ($p<0.05$). It is known that 30% upper extremity and 70% lower extremity should be used for a good performance in taekwondo (Kim et al., 2009). According to the KAT results obtained in our study, where it is thought that different stretching exercises will have a positive effect on kick acceleration performance, it has been observed that static and DSE have an optimal impact on the kick acceleration performance of the athletes. It can be interpreted that there is no obstacle to apply static and DSE in a few weeks before the competition. In the literature, except for a study examining the reliability and validity of the KAT test (Loturco et al., 2014), there is no study used in the comparison between measurements. We think that our study is the first study in the literature that investigates the kick acceleration values obtained with different stretching exercises for taekwondo branch by comparing between measurements.

Limitation

Based on the results of future more comprehensive studies with larger sample groups, we can clearly state that static and dynamic stretching methods are superior to other methods due to the fact that the number of elite athletes in the taekwondo branch of Manisa Celal Bayar University is not sufficient in this study. We had difficulty finding sources because there are few sources similar to this study.

Conclusion

In conclusion, this study examined the effects of different stretching exercises on trunk level and head level kicking performance. After practicing different stretching exercises, participants were asked to perform trunk-level kicking and head-level kicking techniques. It turns out that the results between the two levels differ from each other. In trunk level kicks, 5 of the 12 participants reached the highest performance with SSE, 5 with DSE and 2 with BSE. In head level kicks, 6 out of 12 participants reached the highest performance with SSE, 4 with DSE and 2 with BSE. This shows that the stretching methods in the performance of the participants may vary depending on personal preferences, training programs, muscle-tendon stiffness, psychological states and body structures.

Authors' Contribution

Study Design: SS; Data Collection: EÇ, SS; Statistical Analysis: SS; Manuscript Preparation: EÇ, SS; Funds Collection: EÇ, SS

Ethical Approval

The study was approved by the Manisa Celal Bayar University of Faculty of Medicine Health Sciences Ethical Committee (2024/2359) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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Conflict of interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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