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The effect of static and dynamic muscle stretching as part of warm-up procedures on stretching on isokinetic strength, functional movement screen, flexibility and agility in Korean national foil fencers

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Abstract

The purpose of this study was to investigate the effect of combined static and dynamic stretch as part of warm-up procedures on isokinetic strength, functional movement screen (FMS), flexibility, and agility in Korean national foil fencers. Twelve Korean fencers (mean age 29.3±3.6yrs, Career: 16.6±3.1yrs, Height: 171.4±9.5cm, Weight: 67.3±12.4kg) participated in this study (Male: 7, age 30.0±3.2yrs, Career: 16.7±2.2yrs, Height: 177.1±8.1cm, Weight: 75.1±9.9kg; Female: 5, age 28.4±4.4yrs, Career: 16.4±4.3yrs, Height: 163.4±3.9cm, Weight: 56.3±4.1kg). Fencers measured FMS, isokinetic strength of knee joint, flexibility, agility at pre (1-week) and post (4-week). Fencers performed a warm-up program three times a week for four weeks. As a results, FMS scores (11.8±2.3 to 14.4±1.6, $p<0.05$), strength of dominant knee flexors (115.5±26.0 to 126.0±26.6, $p<0.05$), change-step jump (66.0±6.8 to 69.4±5.6, $p<0.05$), trunk forward flexion (12.0±7.7 to 13.9±6.5, $p<0.05$) were significantly higher in post-test than pre-test, respectively. However, the results for front-rear step, trunk backward extension were not significant differences between pre-test and post-test. These results suggest that the fencing-specific warm-up program based on stretching is effective on strength of knee flexors, agility by increasing flexibility, improving stability, mobility.

Key words: fencing, warm-up, FMS, isokinetic strength, flexibility, agility

Introduction

Fencing is played on a narrow and long piste means a fencing stadium. To win, a fencing match must be scored 15 or higher than the opponent player for three minutes and three rounds. When playing, fencing players repeatedly perform very fast offense and defense changes, direction changes, and momentary movements. In this regard, previous studies on fencing fitness factors have reported that agility, quickness and visual-motor coordination are important (Borysiuk & Waskiewicz, 2008; Gutierrez-Davila, Rojas, Antonio, & Navarro, 2013). Furthermore, anaerobic power is important for fencers (Cerizza & Roi, 1994; Turner et al., 2013). Above all, fencers are important for stability and

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mobility (Czajkowski, 2009; Raghavendra, Murthy, 2010; O'Connor, 1980). Since fencing mainly uses one side, there is a muscle imbalance, so it is important to improve stability, mobility, and muscle balance.

FMS has been used to measure essential movement patterns in dynamic and practical way as physical examination (Cook, Burton, & Hoogenboom, 2006; Schiffman & Zebas, 1997; Chang, Hsueh, & Lo, 2018). FMS includes seven actions, and can be checked joint movement, balance, symmetry, and core stability in detail. If the score is 14 or less based on a total of 21, it can be said that the risk of injury is high (Cook, 2010). Some studies demonstrated differences between uninjured and injured participants in FMS total scores and individual FMS test scores such as deep squat (Butler et al., 2013; Chorba et al., 2010; Peate et al., 2007). Prior researcher reported that experienced rugby athletes with FMS composite scores 14 or less were significantly more likely to sustain time-loss injury in a competitive season than those scoring above 14 (Rodrigues et al., 2017). Muscle strength imbalance associated with injury risk (Edouard et al., 2013; Knapik et al., 1991), is likely to negatively affect athletic performance (Maly, Zahalka, & Mala, 2015). Isokinetic dynamometers is useful for evaluating the lower extremity strength parameters such as peak torque, hamstring / quadriceps muscle strength ratio (H : Q ratio) etc. (Schons et al., 2019; Schons et al., 2018). In athletes including fencing players, a balanced muscle strength ratio between the agonist and antagonist muscle groups is very important for stability and prevention of knee injury (Aagaard et al., 1998; Dauty, Menu, & Fouasson-Chailloux, 2020).

Stretching such as static and dynamic will be effective to improve stability and mobility (Bradley, Olsen, & Portas, 2007; Herbert & Gabriel, 2002; Nelson, Kokkonen, Arnall, & Li, 2012). Stretching improves the stretch ability of muscles and tendon to enable accurate and smooth movement. Although the mechanism for the effect of stretching on mobility is not clear, Fukunaga et al. (1983) reported that muscle blood flow tended to increase after stretching, and Mense and Stahnke (1983) reported that C-fiber activity was low during muscle contraction without ischemia. Particularly, dynamic stretching is necessary for proper authentic movement to occur adequate stability, mobility, and motor control. Improving the range of joint motion will improve the function of the nervous system, which will aid performance (Cook et al., 2010; Matsuo et al., 2013; McGill & Karpowicz, 2009). Overall, regulrar stretching is thought to help mobility, stability, and flexibility improvement in Korean national fencing team athletes. However, it is currently insufficient to apply systematic stretching programs in the field. Therefore, the purpose of this study was to investigate the effect of fencing specific warm-up program based on stretching on functional movement screen, isokinetic strength, flexibility, and agility in Korean national foil fencers.

Methods

Participants

A total of 12 National Korean foil fencers (mean age 29.3±3.6yrs, Career: 16.6±3.1yrs, Height: 171.4±9.5cm, Weight: 67.3±12.4kg) participated in this study study (Male: 7, age 30.0±3.2yrs, Career: 16.7±2.2yrs, Height: 177.1±8.1cm, Weight: 75.1±9.9kg; Female: 5, age 28.4±4.4yrs, Career: 16.4±4.3yrs, Height: 163.4±3.9cm, Weight: 56.3±4.1kg). The participant of this study meets following criteria; Adult who does not take medicine or suffered from illness such as orthopedic disorder. Following completion of a health screening questionnaire, written informed consent was obtained from all participants after explaining the study purpose and procedure. During the experiment, participants were allowed to participate in circuit training, technical training and practice games.

Table 1. *The warm-up program based on stretching.*

No.	Exercise	Number of Repetitions or Duration	Intensity : Based on RPE
1	Fore foot walking	18m piste move once	Light RPE 9-11
2	Rear foot walking	18m piste move once	Light RPE 9-11
3	Joint relaxation while light running	18m piste moving round and round	Light RPE 9-11
4	Heel touch while light running	18m piste moving round and round	Light RPE 9-11
5	Kicking while light running	18m piste moving round and round	Light RPE 9-11
6	Toe touch while light running	18m piste moving round and round	Light RPE 9-11
7	Huddling while walking	18m piste moving round and round	Light RPE 9-11
8	Side lunge while walking	18m piste moving round and round	Light RPE 9-11
9	Quadricep stretch while waking	18m piste moving round and round	Light RPE 9-11
10	Carioca	18m piste moving round and round	Light RPE 9-11
11	Press-up	10 rep. * In place	Light RPE 9-11
12	Shoulder turn	10 rep. * In place	Light RPE 9-11
13	Deltoid muscle stretch while tibialis anterior muscle stretch	2 rep., 10 sec. * In place	Light RPE 9-11
14	Y-T-W-L Stretch	15 rep., 2 set * In place	Light RPE 9-11
15	Back stretch	3 rep., 10 sec. * In place	Light RPE 9-11
16	Adductor muscle stretch	2 rep., 10 sec. * In place	Light RPE 9-11
17	Lunge with side bend	18m piste moving round and round	Moderate RPE 13-15
18	TNS lunge & overhead reach dynamic stretch	18m piste moving round and round	Moderate RPE 13-15
19	Two-foot Jump, front- and rear-step after landing	18m piste moving round and round	Moderate RPE 13-15
20	Two-foot Jump, front- and rear-lunge after landing	18m piste moving round and round	Moderate RPE 13-15
21	Straight hops	18m piste moving round trip twice	Vigorous RPE 15-17
22	Shuffle step	18m piste moving round trip twice	Vigorous RPE 15-17
23	In & out step	18m piste moving round trip twice	Vigorous RPE 15-17
24	Dash after tuck-pike-straddle-modified split jumps	18m piste moving round and round	Very hard RPE 17
25	Dash after short pitch	18m piste moving round and round	Max effort RPE 20

RPE: Perceived Exertion

Methodology

Participants performed a warm-up program based on stretching three times a week for four weeks. Table 1 shows the program sequence. It consists of joint relaxation to increase muscle temperature, to improve static stretching, dynamic stretching, and fencing-specific movements with progressively increased intensity. All participants took body composition, FMS, isokinetic strength, flexibility, and agility measurements at pre (1-week) and post (4-week). Body composition was measured using measuring device (Inbody770, Biospace Ltd., Korea) based on the bioelectrical impedance method. FMS test was measured using FMS test kit based on a total of seven movements with reference to the previous studies (Cook, 2010; Butler et al., 2013). FMS was measured by the same two inspectors. Each FMS movement was recored with video cameras by a research assistant, cameras (HDR-CX405, Sony co., Japan) were set on the front and side respectively. Then two inspectors re-verified the measurement results based on the image of the camera after measurement. Isokinetic muscle strength was measured using the isokinetic dynamometers system (Humac NORM770, Computer Sports Medicine Inc., USA) equipment, evaluated during three trials of the knee joint flexion and extension at 60°/sec (Yapıcı, 2016). Flexibility was evaluated through trunk backward extension measure, and forward flexion, agility was evaluated through change-step jump and front-rear step test. Change-step jump was measured by the number of crossings legs that you would quickly make in front, back, left and right in a 30 cm square for 30 seconds (Chung, Kim, Woo, & Lee, 2016).

The warm-up program included increased muscle temperature and relaxation, static and dynamic stretching, and fencing-specific movements, is presented in Table 1. The intensity of each motion was applied based on the Borg perceived exertion (RPE) scale (6-20) (Borg, 1982). The warm-up program was performed on the 18m piste using ladder training tool, the warm-up program took about 25 minutes. Fencing-specific movements phase was configured to activate the neuromuscular system. In addition to the general fencing training, a warm-up program based on stretching was conducted, the warm-up was performed 3 sessions per week for 4 weeks.

Statistics

All values were presented showed as mean ± standard deviation (SD). Data were analyzed using SPSS version 22.0 for Windows (SPSS Inc., Chicago, Illinois, USA). Paired t-test was performed to determine FMS, isokinetic strength, flexibility, agility between pre and post. The statistical level of significance was defined at α=.05 for all tests.

Results

FMS scores

FMS scores improved significantly after post-test compared to pre-test (11.8±2.3 score to 14.4±1.6 score, $p<.05$) (Table 2).

Isokinetic strength

The 60°/sec flexor peak toque in dominant side muscle strength increased significantly post-test compared to pre-test (115.55±26.02 %BW to

Table 2. FMS change by warm-up program based on stretching.

Warm-Up Program Group (n=12)	Pre-Test	Post-Test	p
FMS (score)	11.75 ± 2.26	14.42 ± 1.56	.001*

Values are mean ± *SD*. *: p<.05.

126.00±26.58 %BW, p<.05) (Table 3), and the non-dominant side showed a significant trend post-test compared to pre-test (p=.084). The 60°/sec extensor peak toque in dominant side muscle strength showed a significant trend post-test compared to pre-test (222.09±41.29 %BW to 236.36±43.25 %BW, p=.089). while no significant difference in the warm-up program for the 60°/sec extensor peak toque in non-dominant side muscle strength between pre- and post-test were found (p=.717).

Flexibility and agility

While no significant difference in the warm-up program for the front-rear step and the trunk backward extension between pre- and post-test were found (p=.241; p=.709). The Change-step jump increased significantly post-test compared to pre-test (66.00±6.85 count to 69.41±5.62 count, p<.05)(Table 4), and the trunk forward flexion increased significantly post-test compared to pre-test (11.98±7.73 cm to 13.88±6.54 cm, p<.05)(Table 4).

Discussion

The purpose of warm-up and stretching routines is to increase the range of motion of skeletal muscles and joint connecting tissue (Decoster, Cleland, Altieri, & Russell, 2005; Wiktorsson-Moller, Öberg, Ekstrand, & Gillquist, 1983). Some studies have reported that stretching, form rolling and heating individually will an increase in tissue extensibility (Halperin et al., 2014; Knight et al., 2001). Also, previous studies have suggested that stretching routines such as static and dynamic will be effective to improve mobility and stability of joint (Bradley et al., 2007; Herbert et al., 2002; Nelson et al., 2012). In this study, FMS scores improved significantly after post-test compared to pre-test. These results demonstrate that the fencing specific warm-up program focus on stretching improved tissue extensibility, range of motion, of skeletal muscles and joint connecting tissue of joint and consequently stability and mobility of joint. Fencing players who mainly use one side have improved mobility and stability through stretching (Swanson, 2006).

Table 3. Isokinetic strength change by warm-up program based on stretching.

Warm-Up Program Group (n=12)		Pre-Test	Post-Test	p
60 °/sec flexor peak toque (%BW)	Dominant side	115.55 ± 26.02	126,00 ± 26.58	.038*
	Non-dominant side	115.55 ± 22.69	123.64 ± 22.46	.084
60 °/sec extensor peak toque (%BW)	Dominant side	222.09 ± 41.29	236.36 ± 43.25	.089
	Non-dominant side	222.82 ± 34.34	226.36 ± 35.91	.717

Values are mean ± *SD*. BW: body weight. *: p<.05.

Table 4. *Flexibility and Agility change by warm-up program based on stretching.*

Warm-Up Program Group (n=12)	Pre-Test	Post-Test	p
Change-step jump (count)	66.00 ± 6.85	69.41 ± 5.62	.038*
Front-rear step (count)	43.00 ± 4.31	44.08 ± 3.99	.241
Trunk backward extension (cm)	55.99 ± 10.73	56.47 ± 9.80	.709
Trunk forward flexion (cm)	11.98 ± 7.73	13.88 ± 6.54	.030*

Values are mean ± *SD*. *: p<.05.

Muscle imbalance is associated with injury risk (Schons et al., 2019; Schons et al., 2018). For fencers, balanced muscle strength ratio between the agonist and antagonist muscle groups, and balanced muscle strength ratio between the left- and right-side muscle groups in agonist can be very important to prevent injury and minimize injury (Aagaard et al., 1998; Dauty et al., 2020; Daneshjoo, Mokhtar, Rahnama, & Yusof, 2012). Isokinetic muscle strength provides reliable information about the muscle strength level and muscle imbalance. The study reported that the program improved the muscular strength ratio. Daneshjoo et al. (2012) demonstrated that injury preventive warm-up programs improved conventional strength ratio and fast/slow speed ratio. In the present study, the 60°/sec flexor peak toque in dominant side muscle strength increased significantly post-test compared to pre-test, and the non-dominant side showed a significant trend post-test compared to pre-test. The 60°/sec extensor peak toque in dominant side muscle strength showed a significant trend post-test compared to pre-test. while no significant difference in the warm-up program for the 60°/sec extensor peak toque in non-dominant side muscle strength between pre- and post-test were found. There was no significant effectiveness in the warm-up program for the dominant and non-dominant ratio in 60 °/sec extensor, and no significant effectiveness in the warm-up program for the dominant and non-dominant ratio in 60 °/sec flexor. There were no significant differences in the 60 °/sec flexor/extensor ratio in dominant and non-dominant side between post-test compared to pre-test. As a result of this study, it is generally meaningful to improve extensor and flexor pre toque. Moreover, no significance was noted for the 60 °/sec dominant and non-dominant ratio in flexor and extensor, however, it was meaningful that the value was less than 10%. Less than 10% means that the dominant non-dominant side muscles are balanced (Humac, 2003). On the other hand, ACL injury can be caused by weakening of the hamstring muscles (Cheung, Smith, & Wong, 2012). Steindler developed that the strength ratio of the hamstring (flexors) / quadriceps (extensors) muscle should be about the rate of 2:3 (i.e Hcon / Qcon of 0.66) (Steindler, 1977). In other words, in order to prevent ACL injury, quadriceps muscle strength should be superior to hamstring muscle strength. This study proved that the fencing specific warm-up program focus on stretching improved muscle strength ratio through knee flexor muscle strength improvement.

In this study, the Change-step jump increased significantly post-test compared to pre-test, and the trunk forward flexion increased significantly post-test compared to pre-test. While no significant difference in the warm-up program for the front-rear step and the trunk backward extension between pre- and post-test were found. Bradley and Portas (2007) presented that flexibility and strength have been considered to be essential in improving sports techniques, performance. Other studies have reported that securing stability provides an advantage for performance (Reed, 2012). For this reason, it can be considered that the positive results of the physical fitness tests such as change-step jump, trunk forward flexion are due to the improvement of stability, mobility, and flexibility. However, this study has limitations in that the number of subjects is insufficient and there is no control group due to the characteristics of national team players. Therefore, it is necessary to verify the stretch effect including a large number of study subjects and control groups in the future.

Conclusions

This study shows that warm-up program based on stretching was effective for improving stability and mobility, flexibility. In conclusion, the program has had a positive impact on performance, such as strength and agility by improving stability, mobility and flexibility.

Conflicts of Interest

The authors declare no conflict of interest. Furthermore, the funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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