

Impact of Effective Frequency Jack-knife Stretching on Preadolescent Male Football Players -Prospective Cohort Study-

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Abstract

Objective: We aimed to investigate the effective frequency of jack-knife stretching in preadolescent male football players.

Methods: We enrolled 47 male preadolescent football players (average age: 12.4 ± 0.6 years old). All participants took surveys at baseline and after intervention for 6 months. The survey items were height, weight, body mass index, anteflexion in sitting, and quadriceps and hamstring tightness. The participants were divided into two groups according to the stretching exercise frequency, where group A performed stretching at least once every 3 days and group B performed stretching less than once every 3 days. After exclusion, 17 participants were enrolled in each group.

Results: There was a significant increase in anteflexion in the sitting position in group A but not group B; moreover, straight leg raising was significantly larger in Group A

Conclusions: Performing jack-knife stretching at least once every 3 days' intervals could improve hamstring flexibility in preadolescent male football players.

Level of Evidence Level \boxtimes

Introduction

Stretching of muscle–tendon complexes occurs with bone growth in length with adaptation involving an increase in the sarcomere number in muscle fibers. In case of an unbalanced increase in the sarcomeres and bone length, there is an increase in muscle tightness [1, 2]. Further, there is a significant increase in thigh muscle tightness with skeletal maturation in preadolescent males [3]. Furthermore, tight hamstring and/or quadriceps muscles have been reported as risk factors for disorders, including Osgood-Schlatter disease and lumbar spondylolysis in preadolescents and adolescents [4, 5]. Increased muscle flexibility allows for increased freedom of movement, which could be of benefit to preadolescents and adolescents. Therefore, maintaining flexible quadriceps and hamstrings muscle could be important for preventing Osgood-Schlatter disease and lumbar spondylolysis.

Previous studies have described three muscle stretching techniques, namely, static, dynamic, and pre-contraction stretches. The traditional and most common type is static stretching, which involves a specific position being held with the muscle being tensed until a stretching sensation is achieved and the position is repeated. There are two types of dynamic stretching: active and ballistic. Active stretching is a means of increasing muscle flexibility while concomitantly improving the function of antagonist muscles. Active stretching involves several limb movements through the full motion range to end ranges. Ballistic stretching involves fast and sudden movements to increase flexibility. Ballistic stretching is no longer recommended given its increased risk for injury. Pre-contraction stretching involves contraction of the primary muscle or its antagonist before stretching. The most common type of pre-contraction stretching is proprioceptive neuromuscular facilitation stretching. Resistance is provided by a partner or an elastic band or strap [6, 7]. Static, dynamic, and pre-contraction stretching can effectively increase muscle extensibility and flexibility. Among these stretching types, static and dynamic stretching exercises are easy and safe to perform by

anyone, including children; moreover, they do not require special equipment or specialized assistants, e.g., a physical therapist. A randomized controlled trial by Meroni et al. compared active dynamic stretching and static stretching and showed that dynamic stretching was more time-efficient and required less compliance to produce effects on flexibility [8]. In a study by Sairyo et al., participants performed active-static stretching for the hamstring muscles in the standing position and this technique was termed as “jack-knife stretching (JKS)” [9]. In our study, we assessed JKS as it is a very simple stretching exercise.

However, it is difficult for preadolescent children to continue a certain number of daily stretching exercises. Furthermore, the JKS frequency and its effectiveness in preadolescents remain unclear. We aimed to investigate the effective frequency of JKS in preadolescent male football players. We hypothesized that lower limb tightness changes with JKS at least once every 3 days' interval.

Methods

This study design was reviewed and approved by Kanazawa University Medical Ethics Review Committee (reference number (2016 – 115) and conducted in accordance with the Declaration of Helsinki; informed consent was obtained from participants and their parents after thorough explanation, in both written and oral formats, regarding the study before enrollment.

We enrolled 47 male preadolescent football players who play for an amateur team under the umbrella of a professional soccer club with an average age of 12.4 ± 0.6 years, height of 153.3 ± 8.9 cm, body weight of 43.9 ± 8.2 kg, and body mass index (BMI) of 18.5 ± 2.0 kg/m². All participants took baseline surveys as described below. The survey items were height, body weight, BMI, anteflexion in sitting, and quadriceps and hamstring tightness. Height and body weight were measured using a portable stadiometer and weight meter with graduations of 0.1 cm and 0.1 kg, respectively. To assess anteflexion in sitting, we used a digital machine for anteflexion measurement (Long-seat anteflexion meter; Takei Scientific Instruments Co., Ltd, Niigata, Japan). Participants were asked to sit with their back against the wall, extend the elbow joint, and grasp the instrument between the thumb and index finger. By moving the instrument forward as much as possible with the knees remaining extended, we could measure the forward movement distance in 0.5 cm as an anteflexion. To assess the quadriceps and hamstring tightness, we measured the heel-hip distance (HHD; cm) in the prone position and the straight-leg-raise angle (SLR; degrees) in the supine position. Quadriceps and hamstring tightness was measured as described below. An examiner applied increasing force on the participant's lower limb until just before the examiner felt resistance. Concomitantly, the second examiner obtained all measurements using a ruler and goniometer for lower limb muscle tightness. All items were measured thrice, and the average values were used for statistics. All examiners were orthopedic surgeons or physiotherapists with more than 5 years of experience.

Figure 2 presents the technique for performing the JKS. In the starting position, the participant squats while holding their ankle joints with their hands. Subsequently, there is gradual extension of the knee joints while maintaining contact between the chest and thighs. The maximum extension position is achieved when the quadriceps femoris is at maximal contraction (Fig. 1) with the position being held for 10 seconds. One set consists of five JKS repetitions with each repetition being held for 10 seconds. We instructed participants to

do one set of JKS daily for half a year. The participants were asked to perform daily stretching and indicated it on the day. After 6 months, we checked all survey items and compliance for JKS frequency.

The participants were divided into two groups according to the JKS frequency as follows: group A included participant who performed their JKS stretching more than one time every 3 days and group B included participants who performed their JKS stretching less than one time every 3 days. Among the 47 participants, we excluded 3 and 4 patients with Osgood-Schlatter disease and low back pain, respectively, as well as 2 and 4 patients in Group A and B, respectively, who were lost to follow-up. Finally, groups A and B each consisted of 17 healthy participants.

All data were analyzed using SPSS 23.0 (IBM SPSS Statistics 23). The paired t-test was used to determine significant differences in the pre- and post-exercise height, weight, BMI, anteflexion in sitting, HHD, and SLR. Between-group comparisons were performed using Student's t-test. Statistical significance was set at 0.05 (two-sided) with 95% confidence intervals. The sample size was calculated using G-Power 3.1 (effect size 0.8, α -error 0.05, and target power 0.95), and a minimum of 15 participants per group was recommended.

Results

There were no significant between-group differences in baseline height, weight, BMI, HHD, and SLR; however, there was a significant between-group difference in the anteflexion in sitting position, which was significantly smaller in group A. There was a significant increase in height and weight after 6 months. In group A, there was a significant increase in anteflexion in the sitting position and SLR as well as a decrease in HHD. Contrastingly, there was no significant change in group B in all items. At 6 months, only SLR showed a significant between-group difference, with it being significantly larger in Group A (Table).

Table:

Baseline and after 6 months within groups

	Group A (n=17)			Group B (n=17)			Group A vs B Baseline	Group A vs B After 6 m
	Baseline	After 6 m	p value	Baseline	After 6 m	p value	P value	P value
Age (yrs)	12.4±0.6			12.8±0.4			0.06	
Height(cm)	151.9±8.2	155.8±8.0	<0.01	154.8±9.8	158.4±9.8	<0.01	0.350	0.410
Weight(kg)	44.1±9.2	47.1±9.6	<0.01	43.6±7.7	47.6±7.8	<0.01	0.868	0.871
BMI(kg/m ²)	18.9±2.4	19.2±2.5	0.057	18.1±1.4	18.9±1.5	<0.01	0.215	0.604
Anteflexion in sitting(cm)	34.9±6.1	40.1±4.6	0.017	40.0±7.9	37.0±10.1	0.208	0.043	0.254
HHD(cm)	12.1±3.4	11.1±2.5	0.066	10.2±3.2	10.0±3.4	0.711	0.095	0.28
SLR(degree)	65.4±7.4	71.8±10.7	0.044	69.4±10.0	62.4±10.9	0.116	0.197	0.016

Values are expressed as mean (standard deviation)

HHD; heel-hip distance

SLR; straight leg raising

Discussion

Our findings indicate that it is necessary to perform at least once every 3 days to improve hamstring flexibility in preadolescent male football players. Contrastingly, the HHD results indicate the need for additional stretching to improve quadriceps flexibility.

The hamstrings are major muscles that control hip and knee joint movement and control pelvis and spine alignment [10, 11]. The hamstrings play an important role in postural alignment, where hamstring shortening could cause posterior pelvic tilt [12]. Changes in the posture caused by hamstring shortening could result in lower back and limb pain [13, 14]. Hamstring stretching is important for preadolescent male football players with a high incidence of lumbar spondylolysis and Osgood-Schlatter disease.

Winter et al. reported that static stretching is characterized by external stretch stimulation on muscle contraction, whereas active stretching is characterized by a reciprocal innervation mechanism for relaxing antagonist muscle contraction [15]. Static stretching adversely affects muscle performance. A meta-analysis by Simic et al. showed that static stretching just before exercise reduces maximum muscle strength [16], whereas active stretching improves muscle strength. Active stretching improves muscle strength by an

average of 13.3% [17]. JKS is considered as active-static stretching of the hamstring muscles and is very simple without the need for tools nor partners. Sairyo et al. reported that performing JKS for 4 weeks increased the finger-to-floor distance to an average of 22.2 cm and increased the pelvis forward inclination angle to an average of 33° [9]. In our study, 6 months of JKS increased anteflexion in the sitting position and SLR to an average of 5 cm and 7°, respectively.

Our findings indicate that a 12-year-old boy grows by about 4 cm and 3.5 kg in height and weight, respectively, within 6 months. Given this growth, there was decreased hamstring flexibility when the stretching frequency was about once a week. Cipriari et al. assessed the effect of stretch frequency on hamstring flexibility and found that approximate hamstring stretching thrice per week was as effective as stretching once daily [18]. Guidelines indicate that the joint range of motion is transiently improved after stretching and chronically improved after 3–4 weeks of regular stretching at a frequency of at least twice to thrice a week among adults [19]. Our findings indicate that JKS performed once every 2 days can improve hamstring flexibility in preadolescent boys.

Holding static stretching for 10–30 seconds at the point of tightness or slight discomfort enhances the joint range of motion, but holding for longer durations has an insignificant benefit [20]. In our study, we instructed the participants to stretch for 10 seconds; however, there is a need for future studies to assess different durations of stretching. Moreover, optimal repetitions for JKS remain unclear. Regarding static stretching, two and four repetitions are recommended [21]. We employed 5 sets to improve upon compliance; however, future studies should assess this problem.

This study has several limitations. First, the JKS has only been studied once and it has not been assessed over a 6-month period. Second, we measured quadriceps tightness using HHD; therefore, the measured values could have changed depending on the muscle tone in the gluteal area, which might have led to inaccurate measurements. Furthermore, the test-retest reliability for anteflexion in sitting, HHD, and SLR remains unconfirmed. Therefore, measurement reproducibility should be considered in future studies. Third, the team we evaluated comprised only boys; therefore, only boys were included in this study. It is unclear how the results of this study apply to girls. However, to our knowledge, this is the first study to report the effect of JKS in preadolescent male football players for 6 months prospectively.

Conclusion

Performing jack-knife stretching at least once every 3 days' intervals could improve hamstring flexibility in preadolescent male football players.

Declarations

Author contributions

J.N., K. Sasaki and H. T. conceived and designed research. J. N, K. Sasaki., K. Shimosaki., K. A. R. M. T. S. Y. M., T. K., K. T., R. Y. and M. K. conducted experiments. K. Sasaki. and T. K. contributed analytical tools and

analyzed data. T.K. and J.N. and H. T. wrote the manuscript. H.T. critically reviewed the manuscript for important intellectual content. All authors read and approved the manuscript.

There are no conflicts of interest to declare.

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Figures



Figure 1

Digital machine for measuring anteflexion (Long-seat anteflexion meter; Takei Scientific Instruments Co., Ltd, Niigata, Japan)

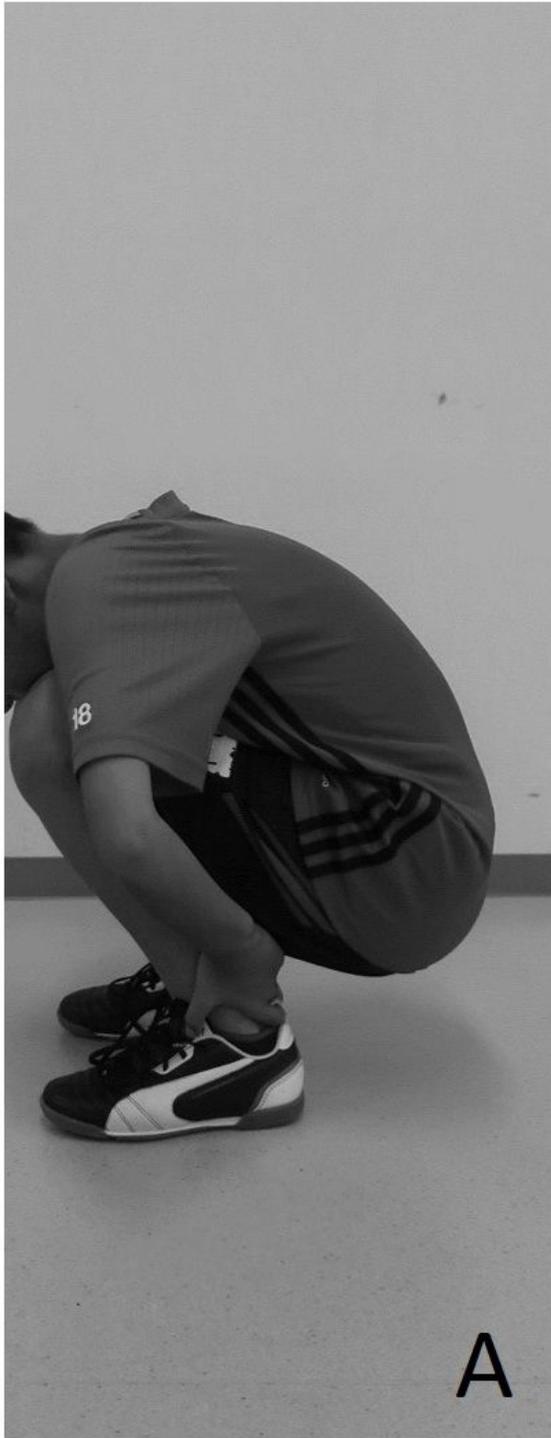


Figure 2

Jack-knife stretching. A: starting position. B: stretching position. In the starting position, the participant squats while holding their ankle joints with their hands with the subsequent gradual extension of the knee joints while maintaining contact between the chest and thighs. The position of maximum extension is achieved when the quadriceps femoris is at maximal contraction with this position being held for 10 seconds.