International Journal of Sports Science 2016, 6(2): 46-51
DOI: 10.5923/j.sports.20160602.05

Is Hamstring Muscle Flexibility Effective on the Active Position Sense of the Knee Joints of the Elite Dancers?

Mehmet Akman[1], Habibe Serap Inal[2,*], Bulent Bayraktar[3], Elçin Dereli[4], Ioakim Ipseftel[1], Turker Sahinkaya[5]

[1]Istanbul Basaksehir Football Club, Istanbul, Turkey
[2]Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Yeditepe University, Istanbul, Turkey
[3]Department of Exercise Sciences, Faculty of Sports Medicine, İstanbul University, Istanbul, Turkey
[4]Department of Physiotherapy and Rehabilitation, Bilgi University School of Health Sciences, Istanbul, Turkey
[5]Department of Sports Medicine, Faculty of Medicine, İstanbul University, Istanbul, Turkey

Abstract We aimed to examine the hamstring muscle flexibility on the active position sense of the knee joints of elite dancers and to understand the proprioceptive accuracy of their knee joints compared to sedentary. Active position sense of knee joint of 20 dancers/20 sedentary were assessed at 20°-40°-60° of extension with/without visual feedback (w/woVF) to observe the mean error of matching angles (EoMA). Hamstring muscle flexibility was assessed with sit and reach test. We found that the flexibility of the right hamstrings was negatively related with active position sense of dancers at the target angles of 20° and 40° wVF ($p < 0.05$; $p < 0.01$). Additionally, the active position sense of the right knee joint (EoMA: 1.95 ± 2.91 degrees) was significantly better than the sedentary (EoMA: 4.2 ± 3.02 degrees) ($p < 0.05$) only at 20°wVF. Furthermore, the flexibility of left hamstrings was also negatively related with the active position sense of dancers only at the target angles of 20° wVF and woVF. The dancers' proprioceptive accuracy was not significantly different then the sedentary on both sides, except at 20°on left side. The flexibility of the hamstrings is negatively affecting the knee joint active position sense of the elite dancers. Therefore, assessing the flexibility of hamstrings muscles of the dancers to protect the knee joint proprioceptive accuracy is important.

Keywords Flexibility, Dance, Proprioception, Accuracy, Error of matching

1. Introduction

With a highly vigorous bouts of aerobic and anaerobic activities [1-4] dance consists of performative and aesthetic elements that distinguishes dancers from other athletes [3] Although the timing and the synchronized movements of the dancers are important for the coordinated figures of joints and each body part, the physical virtuosity in terms of limb coordination, flexibility, and strength are essential [5] since it is a physically demanding competitive sport [6]. During dancing as the patterns and the transitions between the patterns are becoming much more difficult [1, 2]. This may rely on the Fitt's Law that expresses the inverse relationship between the speed and accuracy of movements [5]. On the other hand, Bläsing et al. (2012) remarked the importance of the accuracy of the movement and the position sense of the dancers that are based on the proprioceptive information [7] achieved from somatosensory receptors located in joint capsule, ligaments, muscles, tendons and skin [8]. Especially proprioceptive information provided by the muscle spindles, as tonic receptors sensitive to the rate of length changes of the muscles during initial and terminal stages of the joint movements are the main sources of the position sense of the joints [8-10]. Thus, besides the visual and tactile information [8, 10] the afferent information of the skeletal muscles contribute to proprioceptive acuity that relies on joint position sense [11]. However, the stretching and lengthening trainings of young dancers emphasizing on preserving or increasing the neutral joint range of motion [12] may indicate the risks of disturbed proprioceptive sense of the joints and may even lead to serious extremity injuries [12, 13]. On the other hand, fast repetitive and explosive movements have tendency to increase frictions and stretching over the joint structures of the dancers [1, 14, 15] specifically, the knee joints seems to be vulnerable to overuse or acute injuries [14, 16-18] due to abnormal tissue stress and motor control [19].

Therefore, we aimed to observe the effectiveness of the flexibility of hamstring muscles on the joint position sense of the elite dancers having vigorous knee joint movements.

* Corresponding author:
inal.serap@gmail.com (Habibe Serap Inal)
Published online at http://journal.sapub.org/sports
Copyright © 2016 Scientific & Academic Publishing. All Rights Reserved

2. Material and Methods

2.1. Subjects

The study included 20 male folk dancers (28,85 ± 5,55 years) that had 3-8 years of professional dance experience and 20 male healthy sedentary (26 ± 3,73years) that voluntarily accepted to join to the study. All gave their own written consent to participate in the test protocols of the study, which was approved by the Ethics Committee of Marmara University.

The trial group was excluded among the total of 116 of dancers under the criteria were given in the diagram in Figure 1. The inclusion criteria for the control group as sedentary were same as the trial group except the criteria of professional dancing experience, which was minimum three years.

CRITERIA OF THE STUDY	Total Number N = 116
1- Being a male dancer	n = 60
2- Having at least 3 years of professional experience	n = 33
3- Having no history of recent injury in the low back and lower extremities during the past 6 months, which kept them away from dancing for more than a week	n = 26
4- Able to complete the test procedure without any pain or uncomfortable feeling in the low back or lower extremities	n = 20

Figure 1. Flowchart of the participants according to the inclusion criteria

The physical features of the participants as well as dancing experience and sports background were presented in Table 1. All dancers in the group were right sided except two participants.

Table 1. Demographic characteristics of dancers and sedentary

	Dancers (n=20)	Sedentary (n=20)	p
Participants Descriptions	Mean±SD (Range)	Mean±SD (Range)	
Age (years)	28,85±5,55 (19-36)	26,35±3,73 (20-33)	0,104
Height (cm)	177,40±2,83 (170-182)	178,20±6,44 (168-194)	0,614
Weight (kg)	69,35±5,90 (57-80)	76,15±9,49 (55-92)	0,010*
BMI‡	22,02±1,58 (18,40-25,53)	23,97±2,73 (19,25-29,41)	0,091
Dominantleg	Right 18, Left 2	Right 18, Left 2	
Dancing year	5,8 (3-8)	n/a	
Duration of sports (years)	2,1 (1-8)	n/a	

‡Body Mass Index(kg/m²) *p ≤ 0,05

2.2. Dancing Style

A type of Turkish Black Sea Folk Dance, The Horon, which is a male dance was used as a dancing style in this study. It has anaerobic characteristics with very intense and short duration of movement elements that includes, knee flexion-extension, alternating elements that includes, knee flexion-extension, alternating fast feet tappings, shaking of the shoulders, trunk and the whole body in great complexity. Especially in the final part, Fast Horon, the actively involved leg moves with rapid and coordinated flexion-extension movements while the other leg is weight-bearing on tiptoe and jumping. Following these, the legs are shifted while the other parts of the body are shaken accordingly, as the speed of movements is increased [20].

2.3. Instrument

Sit and reach test (cm) was applied to assess the flexibility of the hamstring muscles of the participants.

Activ Joint position sense (°) was assessed with an electronic goniometer (Lafayette Electronic Goniometer), which was an easy and low cost tool. The goniometer were attached to the pivot of the control arms on the Humac Norm Isokinetic dynamometer projected towards the knee joint. The dynamometer was used as a stable and accurate support for the goniometer to measure the knee joint active position sense. Therefore we utilized it as a guidance device for the arms of the electronic goniometer with an accurate centre of movement since there were no budget for its utilization.

The participants seated with 90° hip and knee joint flexion, and their thigh and crus were secured with straps to focus on the knee joint motion.

2.4. Procedure

Sit and reach test (cm) assessing the flexibility of the hamstring muscles were performed while the participants were sat with hips flexed and knees fully extended in long sitting position. The feet were allowed to be free at neutral position to eliminate the possibility of the involvement of ankle plantar flexors. [21] The distance between the tip of the third finger and the big toe was measured. If participants unable to reach the big toe the measured distance was a value with negative sign, and if it is further from the big toe then the measured distance was a value with positive sign. If they were just able to reach the big toe, then the value was considered as zero (0). The importance of the position of their back and knees was explained before the test, and throughout the test position was checked to ensure it. [21, 22]

The target angles (TA) were 20°-40°-60° of extension [10, 22]. We selected these angles since they were the angles that we assumed the participants might be familiar with them in their daily life due to the normal kinesiological mechanics of the knee joints. For example, while walking, 20°-40° of knee joint are performed during weight bearing stage (stance phase) and while running, 40°-60° of knee joint are performed during non-weight bearing stage (swing phase) [23]. Additionally, they are the angles that the knee joint is kinesiologically vulnerable to injuries [19].

The participants were informed on the test procedure and were asked to perform the test movements with their maximum attention. Three minutes of warm-up and orientation period were given for both group to familiarize the three TAs as 20°-40°-60° before the test procedure. During the test, they were asked to extend their knees actively (isotonic) to attain the randomly given TAs in three trials to achieve the mean error of matching angles (EoMAs) of each participants. There were no force applied by the machine to the knee joints except the actual weight of the lower leg. First, they were asked to observe the graphic on the monitor for visual feedback (wVF) during each of the three trials. Than, the eyes were closed and they were asked to perform the trails without visual feedback (woVF). The data on the best attempt measured was recorded as the EoMAs in absolute values of figures noting the best position sense [24]. Each participant had 3-5 minutes of break between trials and the duration of the tests phase took less than 20 minutes for each participant.

2.5. Statistics

The descriptive statistical data as the means, standard deviations, and ranges were done for each participant. The Kolmogorov Smirnov normality test was applied to understand the distribution characteristics of the data. The significance between the error of matching of two groups with and without vision at 20°-40°-60° were analysed by The Independent Sample T Test. To understand the relationship between the error of matching of the dancers and the sedentary with their hamstring flexibility The Two-tailed Pearson Correlation Test was used. The power analyses of the test were performed to understand the sensitivity of the tests. The results were considered significant at the $p < 0.05$ levels.

3. Results

According to the achieved data, hamstrings of the dancers were significantly more flexible then the sedentary ($p < 0,05$) in the sit-and-reach test (Table 2). The mean active position sense of the dancers and the sedentary indicated as error of matching angles (EoMA) were presented in Table 3. According to these data, dancers' active position sense was better then the sedentary only at 20° w/WoVF on the right side, which were all dominant except the two participants ($p < 0.05$). We have not found any significant difference in the other TAs w/woVF between the groups. In otherwords, the proprioceptive sense of the dancers were not different at 20° w/WoVF in left side, as well as at higher degrees w/WoVF on both sides then the sedentary. Dancing experience was found not related with the accuracy of the active joint position sense of the dancers.

On the other hand, flexibility of the left hamstrings of the dancers was found negatively related with the EoMA at 20° woVF ($p \leq 0,01$) and wVF ($p \leq 0,05$). This was similar in sedentary either (Table 4). On the right side, the EoMA at 20° ($r=-0.432$) ($p \leq 0,05$) and 40° ($r = -0.437$) ($p \leq 0,01$) wVF were also found negatively related with the flexibility of hamstrings muscles. Therefore we may conclude that, the flexibility of the hamstrings is negatively affecting the active position sense of the knee joints of elite dancers. Additionally, visual feedback is important for the accuracy of active position sense of the knee joint of the dancers with flexible hamstrings.

4. Discussion

According to the results, as we aspected, the flexibility of the hamstring muscles of the dancers was higher then the sedentary [1, 2, 12, 16, 22, 25]. These may be due to the characteristics of the dance training aiming to enhance the adaptability and flexibility of the movement patterns [13]. However, the risks of musculoskeletal injuries are increased in the conditions of hypermobility or hypomobility of the joints [18, 22]. On the other hand, Steinberg et al. (2012) were uncertain weather the hypo/hyper range of motion were an injury predictor or if the injury changed the natural range of motion of the dancers [12].

Table 2. The flexibility of the hamstring muscles of the participants according to the Sit and Reach Test

Physical Features		Dancers (n=20)	Sedentary (n=20)	p value
		Mean ± SD (range)	Mean ± SD (range)	
Sit and Reach Test (cm)	Right	3,5 ± 4,81(1-16)	-2,50 ± 4,38(-8-15)	0,000*
	Left	4,0 ± 4,29(1-16)	-2,0 ± 4,26(-7-15)	0,000*

However, hyperflexibility is considered as related with disturbed proprioceptive sense [13]. Therefore, we observed the joint position sense of the knee joint during active extension movement to find out the effects of the flexibility of hamstrings muscles on the proprioceptive acuity of the dancers.

The results of the active joint position sense test at 20-40 and 60 degrees with and without visual feedback were not different in both groups, except the right knees of the dancers that were presenting higher accuracy at the target angle of 20° while eyes were open or closed. Another words, on contrary to our expectations, the accuracy of active position sense in the right knee in higher degrees and in the left knee in all three degrees were similar to the healthy sedentary. Considering the outcomes of Akseki et al. (2008) stated that the knee joint position sense tends to be disturbed at higher flexion angles, and this may possibly be in relation with the overuse injuries and patellafemoral joint syndrome, we may reveal that elite dancers may be under the risks of overuse injuries on their both knee joints [26]. Namely, the decreased accuracy of the joint position sense of the dancers may be due to the excessive and repetitive movements of the joints [1, 14, 16].

That, the fast and strong swinging movements of the right knee joint may tend to decrease the mechanical engagement of patella with its intercondylar grove, and increase its lateral movements causing overuse injuries [2]. On the other hand, on the left knee, which is weight bearing, jumping movements may cause the excessive compressive pressure that may again cause overuse injuries [6, 24]. Therefore, we may consider the risks of overuse injuries in both knee joints of the dancers with disturbed accuracy in active joint position sense. Namely, the higher accuracy of dancers in estimating the amount of the target angle of right knee joint at 20° while the eyes were open or closed may be related with decreased work load to the right knee during the swinging actions which were in form of open-kinetic chain. On the other hand, the left leg performing the jumping movements as in the form of strong closed kinetic chain when the foot touches to the floor in each time may increase the work load of the left joint structures that negatively effect the proprioceptive accuracy, regardless of vision. This may point out that the dancers having swinging and jumping actions simultaneously on their legs may have disturbed proprioceptive accuracy in the higher degrees of their knee joints. However, the jumping left leg may also present the disturbed proprioceptive accuracy in the lower degrees left knee joint.

Table 3. The active position sense of the knee joints of participants

Target Angles			Dancers (n=20) Mean±SD	Sedantery (n=20) Mean±SD	Difference	t	P value
20º	wVF‡	R	22,86±3,12	25,11±3,26	2,25±0,14	-2,226	0,032*
		L	23,33±3,78	24,86±3,91	1,55±0,13	-1,260	0,215
	woVF†	R	23,36±4,08	26,33±3,59	2,97±0,49	-2,438	0,020*
		L	24,41±3,62	25,55±3,86	1,14±0,24	-1,294	0,203
40º	wVF	R	41,85±2,38	42,63±2,18	0,78±0,20	-1,082	0,286
		L	43,23±2,25	42,51±2,58	0.72±0.33	0,935	0,355
	woVF	R	42,81±2,65	42,66±2,43	0.15±2.51	0,186	0,854
		L	43,66±4,49	42,68±1,98	0.98±2.51	0,895	0,376
60º	wVF	R	61,38±1,92	61,60±1,65	0.22±0.27	-0,381	0,705
		L	62,50±1,90	61,93±1,44	0.57±0.76	1,060	0,296
	woVF	R	61,55±2,63	61,05±2,74	0.50±0.11	0,588	0,560
		L	62,08±1,20	61,96±1,98	0.12±0.78	0,224	0,824

‡with visual feedback †without visual feedback
*p ≤ 0,05 ;
** p ≤ 0,01 Significance

Table 4. The relation between the flexibility of the hamstrings muscles and the active position sense of the knee joints of participants

Target Angles			Dancers (n=20)		Sedentary (n=20)	
			r	p	r	P
20º	wVF‡	R	-0,432	0,005*	-0,347	0,028*
		L	-0,400	0,011*	-0,339	0,032*
	woVF†	R	-0,263	0,101	-0,177	0,275
		L	-0,403	0,010**	-0,338	0,033*
40º	wVF	R	-0,437	0,005**	-0,234	0,147
		L	-0,194	0,229	-0,247	0,124
	woVF	R	0,093	0,569	0,080	0,623
		L	-0,063	0,701	-0,263	0,101
60º	wVF	R	-0,025	0,878	0,027	0,870
		L	-0,126	0,438	-0,067	0,683
	woVF	R	0,070	0,667	0,046	0,778
		L	-0,154	0,342	-0,266	0,097

‡with visual feedback †without visual feedback

Although hamstring muscle flexibility is essential for the performance dancers [1, 2, 7], we found that this may negatively affect the active position sense of the dancers. The flexibility of the right hamstrings was negatively related with the active position sense of the dancers at the target angles of 20° and 40° of the right knee joint with visual feedback. The similar relation was found for the left hamstrings of the dancers only at 20° of the left knee joint with and without visual feedback. Thus, although the increased flexibility of the hamstrings may be due to the characteristics of the dance training aiming to enhance the adaptability and flexibility of the movement patterns required during dancing [27], it may decrease the accuracy of the active position sense of the knee joints, and it could not be compensated with the visual feedback [10, 27]. Therefore, we may conclude that, the accuracy of the active position sense of the knee joints of the dancers may be disturbed, as the flexibility of the hamstrings increase. Thus, we may suggest the clinicians as doctors and physiotherapist, to consider the importance of the flexibity of hamstrings muscle of the dancers to protect the knee joint proprioceptive accuracy.

Additionally, although they were all skilled, experienced dancers, dancing experience was not found related with the accuracy of the active position sense of the knee joints of the dancers on contrary to the outcomes of Bläsing et.al. (2012) stating that the skilled dancers mainly rely on their proprioceptive sense for the accuracy and synchronization of the movement patterns [7].

Unfortunately, the achieved results of the tests have low statistical power. This may be due to the relatively small sample size that may be considered as the limitation of this study. However, the assessment of the proprioceptive sense and the muscle flexibility of the dancers may contribute to fulfil the lack of studies identifying the objective assessments in dance literature as also stated by McCabe et al, 2013.

5. Conclusions

We can conclude that elite dancers' active position sense was not significantly different then the healthy sedentary, except at 20° on right side, which could be searched on. The excessive workload of the knee joints during dancing may be one of considerations on this issue. The flexibility of the hamstrings is negatively affecting the active position sense of the knee joints of elite dancers. Thus, we are in the opinion that, although muscle flexibility is important aspect of the dancers' body, however, as *Bläsing* et al. (2012) stated this should be within the personal limitations of the dancers to achieve the required joint stability and dynamics [7]. Thus, under the context of the prevention, the assessment of active joint position sense of the dancers should not be disregarded and should be performed besides the hamstring muscle flexibility tests especially in elite dancers.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Mustafa Erdogan, The General Director and Choreographer, and the dancers of the Fire of Anatolia Dance Group for their patience and attentive support to fulfil the requirements of the methodology of this study.

REFERENCES

[1] Angioi, M. (2010). Evaluation of physical fitness in relation to performance and injury severity in contemporary dance. [Thesis]. University of Wolver- hampton.Evidence based prevention of hamstring injuries in sport. BrJ Sport Med 2005;39:319-323. doi:10.1136/bjsm.2005.018549.

[2] Bria S, Bianco M, Galvani C, Palmieri V, Zeppilli P, Faina M. Physiological characteristics of elite sport-dancers J Sports Med Phys Fitness 2011; 51:194 -203.

[3] Clippinger K. Dance Anatomy and Kinesiology. Champaing Illinois,: Human Kinetics; 2007.

[4] Fitt SS. Dance Kinesiology. NewYork: Schirmer/Thomson Learning Inc.; 1996.

[5] Schmidt RC, Corey D. Fitzpatrick P, Riley M. The Oscillatory Basis of Fitts' Law. In: Bardy BG, Bootsma RJ, Guiard Y. (Eds). Studies in Perception and Action. III B. New Jersey: Lawrence Erlbaum Associates Publisher, 1995: 95-98.

[6] McCabe TR, Wyon M, Ambegaonkar JP, Redding E. A bibliographic review of medicine and science research in dance sport. Med Probl Perform Art. 2013; 28 : 70-79.

[7] Bläsing B, Calvo-Merino B, Cross ES, Jola C, Honisch J, Stevens CJ. Neurocognitive control in dance perception and performance. Acta Psychologica. 2012; 139: 300-308.

[8] Stillman BC. Making sense of proprioception: The meaning of proprioception, kinesthesia and related terms. Physiotherapy 2002; 88: 667-76.

[9] Lephart SM, Riemann BL, Fu FH. Introduction to the semsorimotor system. In: Scott M. Lephart, Freddie H. Fu (Eds.) Proprioception and Neuromuscular Control in Joint Stability. Illinois: Human Kinetics, 2000.

[10] Riemann BL, Lephart SM. The Sensorimotor System, Part II: The Role of Proprioception in Motor Control and Functional Joint Stability. J Athlet Train 2002; 37: 80 – 84.

[11] Felson DT, Gross KD, Nevitt MC, Yang M, Lane NE, Torner JC, Lewis CE, Hurley MV. The effects of impaired joint position sense on the development and progression of pain and structural damage in knee osteoarthritis. Arthritis & Rheumatism (Arthritis Care & Research) 2009; 61: 1070-1076.

[12] Steinberg, N., Hershkovitz, I., Peleg, S., Dar, G., Masharawi, Y., Heim, M., & Siev-Ner, I. Range of joint movement in female dancers and nondancers aged 8 to 16 years: anatomical

and clinical implications. The American Journal of Sports Medicine, 2006; 34(5), 814-823.

[13] Fatoye F, Palmer S, Macmillan F, Rowe P, van der Linden M. Proprioception and muscle torque deficits in children with hypermobility syndrome. Rheumatology 2009; 48:152-157. Doi:10.1093/rheumatology/ken435.

[14] *Albisetti W, Bartolomeo O, Gabbiadini S, Ventura A, Parrini M.* Surface EMG evaluation of patellafemoral pain syndrom in a Professional ballet dancer: A case report. Med Probl perform Art 2008; 23: 29 -32.

[15] de Araújo GM, Monteiro HL, Pastre CM. Musculoskeletal disorders (MSDs) in dancers and former dancers participating in the largest dance festival in the World. Sci Sports 2013; 28: 146-154.

[16] Anderson SJ. Sports Injuries. Curr Probl Pediatr Adolesc Health Care 2005; 35: 110 - 164.

[17] Ayala F, Sainz de Baranda P, De Ste Croix M, Santonja F. Reproducibility and criterion-related validity of the sit and reach test and toe touch test for estimating hamstring flexibility in recreationally active young adults. Physical Therapy in Sports. 2012, 13(4):219-226.

[18] Steinberg N, Siev-Ner I, Peleg S, Dar G, Masharawi Y, Zeev A, Hershkovitz I. Joint Range of Motion and Patellofemoral Pain in Dancers. Int J Sports Med 2012; 33: 561–566.

[19] Baker V, Bennell K, Stillman B, Crossley K. Abnormal knee position sense in individuals with patellofemoral pain syndrome. J. Ortop Res 2002; 20: 208 - 214. DOI: 10.1016/S0736-0266(01)00106-1.

[20] Baykurt S. Anadolu Kulturleri ve Turk Halk Danslari (Anatolian Cultures and Turkish Folkloric Dances) Ankara: Kültür Ajans; 1995.

[21] Kendall FP, McCreary EK, Provance PG, Rodger MM, Romani WA. Muscle Testing and Function with Posture and Pain. Philadelphia: W.B. Saunders *Company*; 2005: 69-118.

[22] Gannon LM, Bird HA. The quantification of joint laxity in dancers and gymnasts. J Sports Sci 1999; 17: 743-750.

[23] Neumann DA. Kinesiology of the musculoskeletal system. Foundations for Rehabilitation. 2nd ed. St.Luis:Mosby Elsevier; 2004.

[24] Ozkul F, Erol DB, Demirbas BS, Inal S. Evaluation of elbow joint proprioception with RehabRoby: a pilot study. Acta Orthop Traumatol Turc. 2012; 46: 332-338.

[25] Angioi M, Metsios G, Koutedakis Y, Wyon MA. Fitness in contemporary dancer: A systematic review. Int J Sports Med 2009; 30: 475 - 484.

[26] Akseki D, Akkaya G, Erduran M, Pınar H. Proprioception of the knee joint in patellofemoral pain syndrome. Acta Orthop Traumatol Turc 2008; 42: 316-321.

[27] Kiefer AV, Riley MA, Shockley K, Sitton CA, Hewett TE, Cummins-Sebree S, Haas JG. Multi-segmental postural coordination in professional ballet dancers. Gait & Post 2011; 34: 76-80.