JOINT POSITION SENSE

IN TURKISH PROFESSIONAL BALLET DANCERS[3]

Arman ESEN[1]

Gulbin RUDARLI NALCAKAN[2]

S. Rana VAROL[2]

ABSTRACT

Purpose. The aim of this study was to compare the joint position sense (JPS) between professional ballet dancers and non-dancers controls.
Methods. The study group consisted of thirty six professional ballet dancers and gender-matched controls. Measurements were performed on each group after filling out a questionnaire about their dance and injury backgrounds. Left and right arm flexion 50º and abduction 50º and left and right leg flexion 55º and abduction 70º were selected as measurement movements from dancers' routine practice. Subjects repeated each movement six times with five-second intervals. Acumar Digital Inclinometer was used for JPS measurements and Gollehon Extendable Goniometer was used for validating the accuracy of measurements. The outcome measurement was an error score calculated as the mean absolute deviation (MAD) between the target and replicated angle.
Results. JPS was significantly better in the dancer group compared to the control group. JPS did not show a significant difference between males and females. It was found no correlation between dance year and MAD values, except for the left hip abduction MAD levels ($p<0.05$). No significant difference was found between the right and left extremities. In comparing the upper and lower extremities, there was no significant difference except for the comparison of right shoulder and right hip flexion.
Conclusion. Professional ballet dancers demonstrated greater accuracy in joint position. "Continued and repeated practice" may improve proprioceptive responses of dancers.
***Key words*:** Proprioception, joint position sense, dancer, shoulder, hip

TÜRK PROFESYONEL BALE DANSÇILARINDA EKLEM POZİSYON HİSSİ

ÖZET

Amaç. Bu çalışmada amaç profesyonel bale dansçılarının omuz ve kalça eklem pozisyon hissini (EPH) saptamak ve dansçı olmayan kontrol grubu ile karşılaştırmaktı.
Yöntem. Çalışma grubu Ankara ve İzmir Devlet Opera ve Balesi'nde çalışan otuz altı profesyonel bale dansçısı ile aynı sayıda ve cinsiyetteki kontrol grubundan oluşmuştur. Gönüllüler dans ve sakatlık geçmişlerine yönelik bir anket doldurmuştur. Ölçüm hareketleri dansçıların alışık olduğu fakat kontrol grubunu da zorlamayacak açılardan seçilmiştir: sol ve sağ kolda 50º fleksiyon ve 50º abdüksiyon ve sol ve sağ bacakta 55º fleksiyon ve 70º abdüksiyon. Her bir hareket 5 saniye arayla altı kez tekrar edilmiştir. Acumar Dijital İnklinometre EPH ölçümü için ve Gollehon Uzayabilir Gonyometre ölçümlerin doğruluğunun kontrolünde kullanılmıştır. Elde edilen veriler hedef ile ulaşılan açı arasındaki ortalama hata skoru (OHS) olarak kaydedilmiştir.
Bulgular. Dansçıların EPH verileri kontrol grubuna göre istatistiksel olarak düşüktü ve bayan ve erkek dansçılar arasında farklılık yoktu. Dansçıların sadece sol kalça abdüksiyon OHS değeri ile dans yaşı arasında korelasyon görülmüştür. Sağ ve sol ekstremiteler arasında anlamlı farklılık bulunmazken, alt ve üst ekstremite karşılaştırıldığında, sadece sağ omuz ile sağ kalça fleksiyon verileri arasında anlamlı farklılık görülmüştür.
Sonuç. Profesyonel bale dansçıları EPH ölçümünde istatistiksel olarak anlamlı bir doğruluk göstermiştir. "Düzenli olarak tekrar edilen alıştırmalar" dansçıların proprioseptif cevaplarını geliştirmiş olabilir.
Anahtar Kelimeler: Propriosepsiyon, eklem pozisyon hissi, dansçı, omuz, kalça

[1] Dance Academy, Izmir- TURKIYE

[2] Ege University, School of Physical Education and Sport, Department of Coaching Education, Izmir – TURKIYE

[3] Bu çalışma Arman Esen'e ait "Dans Eğitiminin Eklem Pozisyonunu Algılama Düzeylerine Etkisi" adlı yüksek lisans tezinden hazırlanmıştır ve 12. Uluslararası Spor Bilimleri Kongresi'nde sunulmuştur.

INTRODUCTION

The scientific term proprioception comes from the Latin term “proprius” meaning “one’s own” and “-ception”—to perceive, the ability to sense and perceive oneself (Yılmaz & Gök, 2006; Hagert, 2010). It is defined as body awareness, knowing just where the body is in space or the physical feeling of our moving body. It is often referred to as the “sixth sense.” This body sense, however, is more than a feeling of movement, which “is tied to our feeling of muscle tone, perceptions of effort and of balance” (Batson, 2008). The proprioceptive receptors are located in the muscles, tendons, ligaments, joint capsules and the skin and can be found within and around surrounding joints (Ramsay & Riddoch, 2001).

Dancers, refer to this sense usually by using terms such as “kinaesthesia” (to move to sense), “muscle sense” or “sense of movement” (Batson, 2008). Although all of these terms do not mean the same thing, proprioception can be understood as an all encompassing term including the conscious and unconscious activities. For that reason, different proprioception senses are divided into neuromuscular and somatosensory senses. Neuromuscular senses reflect the unconscious control in joint proprioception, including reflexive, automatic and voluntary activity such as posture control, joint stability and muscle reaction times (Hagert, 2010). The somatosensory senses, on the other hand, are conscious appreciations of proprioception, resulting in awareness of movement and position. There are three submodalities of conscious proprioception: kinesthesia, joint position sense (JPS) and sense of tension or force (Marmeleira et al, 2009; Rein et al, 2011). While sense of tension or force means defining and evaluating ability to strength of the joints, kinesthesia is correlated with position sense of relative muscle, tendon and ligament in the specific situations. Kinesthetic memory covers sequential shift and learning for routine and repetitive movements (e.g. dancing). Proprioception, as a dynamic sense, allows continuous accommodation and adaptation in an active environment (e.g. dancing or while trying walking across a crowded room) (Yılmaz&Gök, 2006).

The best way of proprioceptive ability development provide successful motor learning in every sport activities, performance of movements and mastery skills for the high levels sports. In addition, increase in proprioceptive joint ability is important in rehabilitation and sports injury prevention as well.

Ballet is a form of athletic activity which requires exquisite control of particular postures and exceptional athletic ability. In order to reach professional level, extreme and extended training is required. For this reason, professional ballet dancers undertake strenuous physical activity in daily classes, with frequent repetition of specific movements and movement patterns (Ramsay&Riddoch, 2001). That is why they “know where to place their arms in fifth position, even with their eyes closed…they also know just how to move smoothly and accurately in ensemble – standing, sliding, and turning – without bumping into other dancers” (Batson, 2008).

Although there are many studies on proprioception, few studies have examined the effects of ballet dance exercise and the position of professional ballet dancers. One of the studies made on JPS for shoulder and elbow joints of professional ballet dancers found out that they were affected positively (Ramsay&Riddoch, 2001). Other studies concentrated on postural control and ankle stability and which was not influenced (Rein et al, 2011; Schmitt,Kuni& Sabo, 2005) by the profession. Therefore, the purpose of this study was to evaluate the joint position sense for shoulder and hip between professional ballet dancers and controls.

MATERIAL AND METHODS

This study was approved by the ethics committee of Faculty of Medicine in Ege University (decision number: 12-1.1/8). All procedures were followed according to the declaration of Helsinki. Prior to inclusion in the study the consent of all subjects was obtained.

Each subject's descriptive data and personal information was gathered by means of a questionnaire which integrated information on age, gender, dominant leg and arm, profession, training time, injuries or disease of the skeletal system in the past.

Subjects: Thirty-six professional ballet dancers and thirty-six healthy controls were recruited for this study. At the time of the study all the volunteers were physically fit with no arm and leg injuries. The control group (ages mean 24.9±4.7 years) consisted of volunteers with no prior dance or specific sport training. The dancer group consisted of professional ballet dancers from the Ankara and Izmir State Opera and Ballet. In the group there were 21 female (58%) and 15 male (42%) dancers and their ages ranged from 21 to 42 (mean 29.1 years). All of the subjects in the dancer group were the graduates of dance academy. Their professional dance training consisted of 10 to 56 hours per week (mean 30.1±9.5 hour). According to the results of the questionnaire the training age of the dancers was similar for men (19.1±5.2 years) and women (17.8±5.1 years); Twenty-seven of the dancers were right-handed, seven were left-handed and two of them were using both hands effectively; twenty dancers were right legged, eleven were left legged, and five of them were using both legs effectively.

To avoid a negative bias on JPS due to neuromuscular fatigue, all subjects were discouraged from sport on the day of investigation. No specific proprioceptive training techniques were practiced in the training group. No particular preparation, e.g. warm up, stretch, was performed immediately prior to the test.

***Joint Position Sense Test*:** The measurements were carried out by an experienced staff. Before starting the test each subject tried all the positions once. Each leg and arm position was repeated six times and then recorded. In order to ensure the accuracy of the measurement five-second intervals were given. The target positions were selected among the routine practices of the dancers, without forcing the range of motion. The test trials included left arm flexion 50º (1st position) and abduction 50º (2nd position), right arm flexion 50º (1st position) and abduction 50º (2nd position), left leg flexion 55º (Battement Jeté) and abduction 70º (Battement Jeté) and right leg flexion 55º (Battement Jeté) and abduction 70º (Battement Jeté).

Generally, flexion of arms, abduction of arms, and flexion or abduction of leg movements are named as "1th position, 2th position and battement Jeté" in classic dance education, respectively. Arms are maintained the curved shape, are brought up so that the tips of the fingers are in line with the navel or no higher than the sternum in the first position. Arms are out to the sides, angled down and forward, with palms facing forward. Elbows are slightly lower than the shoulders, and wrists are level with the elbow in the second position (Wikipedia.org). Battement Jeté is a battement normally taken to anywhere from 2 cm off the floor up to 45 degrees, depending on the style (superglossary.com).

The neutral position of the subject's shoulder and hip were noted as 0º and target angles of motions were demonstrated. Obtained measurements were evaluated according to mean absolute deviation (MAD). Joint position sense was regarded as improved when the MAD values were near to "0".

The tests were completed within 12 days by testing 3 to 5 persons per day. They were performed within a total of 36 hours with an average of a half-hour test period for each subject. The tests were performed in a quiet training hall between 11:00 a.m. and 15:00 p.m.

In this study, a standard plinth and ACUMAR™ digital inclinometer, (Lafayette Instrument Company, Model ACU 360, IN, USA) an instrument automatically calculating and displaying the actual range of motion of the joints, was used for all inclinometric measurements. The manufacturer specifications indicate that Acumar is capable of measuring a range up to 180° with an accuracy of ±1°. Also in this study, for all goniometric measurements, a 12-inch plastic BASELINE® goniometer (Lafayette Instrument Company, Model 12-1000, IN, USA) was used for validation the accuracy of measurements. The reliability and validity of these instruments for measuring shoulder mobility measurements were reported by the technical report of Kolber and Hanney (2012).

Statistical Analysis

The Statistical Package for the Social Sciences SPSS 19.0 (SPSS, Chicago, IL) was used to perform all statistical analyses in the study. Level of significance was set at 0.05 ($P < 0.05$) for all comparisons. The Shapiro-Wilk Test showed that the data did not present a normal distribution. Mann-Whitney test was used to examine the differences between the values from both groups, the Wilcoxon's signed rank test was used in comparing right- left and upper-lower extremities data and the correlations were determined with Spearman test.

RESULTS

The level of joint position sense was significantly higher in the dancer group compared to the controls ($p<0.001$) at the target angles in shoulders and hip (Table1).

Table 1: Mean absolute deviation (degree) between the target and replicated angle in shoulder and hip of dancer and control groups.

MOTIONS MAD VALUES	Dancer group (n=36)			Control group (n=36)			P
	median	**min**	**max**	**median**	**min**	**max**	
Right SF MAD (°)	1.17	0.17	2.67	3.50	0.67	10.5	<0,001
Left SF MAD (°)	1.25	0	3.67	3.92	0.33	19.0	<0,001
Right SA MAD (°)	1.00	0	4.50	1.83	0.33	19.0	<0,001
Left SA MAD (°)	0.92	0	6.00	2.08	0.33	19.0	<0,001
Right HF MAD (°)	0.67	0	3.00	2.50	0.67	11.5	<0,001
Left HF MAD (°)	0.67	0	3.33	2.42	0.17	11.5	<0,001
Right HA MAD (°)	0.92	0	3.67	1.67	0.33	5.00	0,001
Left HA MAD (°)	1.00	0	3.00	1.67	0.33	13.0	0,001

MAD: Mean absolute deviation, SF: Shoulder flexion, SA: Shoulder abduction, HF: Hip flexion, HA: Hip abduction

Joint position sense did not show a significant difference for all parameters between males and females in the dancer group (Table 2) and also in control group ($p>0.05$).

Table 2: Male and female dancers mean absolute deviation values differences

GENDER MAD VALUES	Men dancers (n=15)			Women dancers (n=21)			P
	median	**min**	**max**	**median**	**min**	**max**	
Right SF MAD (°)	1.16	0.33	2.0	1.17	0.17	2.67	0.94
Left SF MAD (°)	1.50	0.50	3.67	1.17	0	3.67	0.19
Right SA MAD (°)	1.00	0.33	4.50	1.00	0	2.67	0.87
Left SA MAD (°)	0.83	0.33	6.00	1.00	0	3.17	0.31
Right HF MAD (°)	0.83	0	2.50	0.67	0	3.00	0.14
Left HF MAD (°)	0.83	0.33	3.33	0.67	0	2.67	0.15
Right HA MAD (°)	0.67	0.17	3.67	1.00	0	2.50	0.85
Left HA MAD (°)	1.17	0.17	3.00	0.83	0	2.00	0.33

MAD: Mean absolute deviation, SF: Shoulder flexion, SA: Shoulder abduction, HF: Hip flexion, HA: Hip abduction

In the dancer group, there was no correlation between training year and MAD values except for the left hip abduction MAD levels ($p<0.05$) (Table 3).

Table 3: Correlation between MAD values and training years of dancers

MAD values	Training years
Right SF MAD (°)	0.18
Left SF MAD (°)	0.30
Right SA MAD (°)	0.16
Left SA MAD (°)	0.16
Right HF MAD (°)	-0.90
Left HF MAD (°)	0.03
Right HA MAD (°)	0.14
Left HA MAD (°)	-0.35 *

MAD: Mean absolute deviation, SF: Shoulder flexion, SA: Shoulder abduction, HF: Hip flexion, HA: Hip abduction *p<0.05, **p<0.01

In the comparison of the right and left extremities, there are no significant differences between MAD values of legs and arms in dancer and control groups ($p>0.05$) (Table 4).

Table 4: Differences between right and left extremities in dancer and control group

MAD VALUES	P VALUES	
	Dancer group	**Control group**
Right SF MAD (°)- Left SF MAD (°)	0.32	0.41
Right SA MAD (°)- Left SA MAD (°)	0.81	0.91
Right HF MAD (°)- Left HF MAD (°)	0.10	0.19
Right HA MAD (°)- Left HA MAD (°)	0.92	0.85

MAD: Mean absolute deviation, SF: Shoulder flexion, SA: Shoulder abduction, HF: Hip flexion, HA: Hip abduction

In the comparison of joint position sense of the upper and lower extremities, right hip flexion MAD values were significantly better than right shoulder flexion values ($p<0.05$) in the dancers; left hip flexion MAD values were better than left shoulder values and right hip abduction MAD values were better than right shoulder abduction values ($p<0.05$) in the controls; the remaining comparisons did not reach statistical significance was shown in Table 5.

Table 5: Joint position sense differences between upper and lower extremities in dancer and control groups

MAD VALUES	P VALUES	
	Dancer group	**Control group**
Right SF MAD (°) - Right HF (°)	0.02 *	0.4
Left SF MAD (°) - Left HF MAD (°)	0.09	0.02 *
Right SA MAD (°) - Right HA MAD (°)	0.45	0.02 *
Left SA MAD (°) - Left HA MAD (°)	0.60	0.07

MAD: Mean absolute deviation, SF: Shoulder flexion, SA: Shoulder abduction, HF: Hip flexion, HA: Hip abduction *p<0.05

DISCUSSION

Although many studies are made on the topic of proprioception since Sherrington introduced the term in 1906, few studies are made discussing its relation to professional ballet dancers. For that reason, in this study we have tried to evaluate the relationship between dance training and joint position sense. This relationship continues to be a popular topic for the researchers.

Joint position sense is one of the most commonly used measures of proprioception and in this study by concentrating on hip and shoulder areas we have conducted measurements on professional ballet dancers and volunteers with no prior dance or specific sport training. Since tactile feedback has been suggested to affect proprioception in the knee and ankle, in this study we have used attached inclinometer (Model ACU 360) to limit the tactile feedback. The reliability of the measuring instruments used in the study is highlighted with current studies made on them. Also the measurement techniques used within the study are valid and conducted by experts.

At the beginning of the study, we had a hypothesis that regular and serious exercises would affect JPS positively at target region of body. Our study has found out that for both legs and arms, dancers have a more improved JPS on the shoulder and hip than non-dancers. Ramsay and Riddock (2001) in their study about the position-matching in the upper limb of ballet dancers have found similar results on the shoulder and elbow joint by using different methods of measurement.

However, Rein et al, (2011) compared the postural control and functional ankle stability between professional and amateur dancers as well as controls. According to the results of the study, “professional dancers showed a significantly increased plantar flexion of both feet, had a significant better postural control at all tested positions, a specific balance distribution and greater range of motion in comparison to all other groups”. They also found out that “peroneal reaction time and the position sense test were not influenced by the profession. The position sense test only showed significant differences between professionals, amateurs and controls at the position of 130° for the right leg. The results connected to limitation of the test: a difference of 2° could be within measurement error rather than a real difference with the use of a standard goniometer”.

Also, It is demonstrated deficits in JPS in the knees of professional ballet dancers (Barrack et al, 1983), professional folk dancers (Akman, 2007) and in the dominant shoulder of overhand-throwing athletes (Allegrucci et al, 1995). The investigators of these studies attributed the proprioceptive deficits to chronic capsular laxity (hypermobility) and joint deformities (Delforge, 2002).

Although proprioception insufficiency occurs due to lack of physical exercise as mentioned above, it might also occur with

aging. Muscle mass declines with age and this situation results in the decrease of proprioception sensitivity. For instance, Marmeleira and et al (2009) argue in their article that 12-week creative dance exercises "increase significantly knee position sense, knee kinesthesia (during flexion) and arm positioning" and therefore enhance proprioception in older adults.

It is highly stressed that "exercise brings about changes on processes that are better presented in active than passive mode". Information is provided to the central nervous system by the peripheral receptors; the tendinous and neuromuscular ones. "Several factors linked with exercise may affect these receptors: better visco-elastic properties of muscular tissue, enhanced oxygenation, and increased body temperature because of vasodilatation". It is argued that these effects improve the functioning of the receptors involved and therefore advance the kinesthetic sensibility. It is also claimed that "the effects of exercise may also be explained by central factors and particularly those concerning the motor command" (Bouet & Gahery, 2000).

Efficacy of proprioceptive exercises for injury prevention and rehabilitation after injuries is also analyzed in a study made by Hazneci and et al (2005) in which they concluded that "isokinetic exercises have positive effects on passive position sense of knee joints, increasing the muscular strength and work capacity". Eils and Rosenbaum (2001) also, proved that joint position sense, postural balance and muscle reaction time are significantly improved by proprioceptive exercises in patients with chronic ankle instability.

The absence of any differences between right and left extremities and also between upper and lower extremities in our study was attributed to that both sides of body were worked equally in ballet dancing training. This is thought to be a minimal risk of injury due to one-sided loading in dance. Akman (2007) evaluated knee joint position sense with different angles on folk dancers, and Bullock-Saxton, Wong & Hogan (2001) also measured the knee joint position sense with standing position (the influence of body weight) and concluded that dominance on extremities is not an effecting factor on the accuracy of JPS.

It is reported that a training program with many closed kinetic chain exercises and increasing the number of repetitions and rate of contractions is better than a traditional muscle strengthening program (open kinetic chain and graduated weight-resisted exercises) in improving proprioception (Delforge, 2002). Accordingly, although JPS is also expected to increase with training experience (total training time), no correlation was found between training year and investigated performance measures. This could be resulted from very high dance experience levels of our study sample, that is at least 11 years, and minimum of 11-year dance experience of the dancers could lead them to reach their maximum limits in the context of JPS. Therefore, further training experience could lead no further improvements in JPS resulting in no correlation between training age (11 to 31, mean 18.4 years) and MAD values in the dancer group is an expected result.

Although certain studies discuss that "professional dance training strengthens the accuracy of proprioceptive inputs and shifts sensorimotor dominance from vision to a more internally-based system of reference" (Batson, 2009), there are some studies which argue that there is no improvement in angle replication as a result of dance training. Schmitt, Kuni & Sabo (2005), for instance, have found in their study that "dance training did not increase the peak torque ratio of plantar flexion to dorsiflexion PF/DF within 5 months [of professional dance training]". And they also argued that "ballet training alone without concurrent additional coordinative training [did] not lead to improvements in ankle joint position sense or improved measures of balance".

The research showed joint position sense results which reflect the part of proprioception for Turkish ballet dancers who made ballet training exercises in many years. It also highlights that dance training improves joint position sense, this being consistent with earlier studies. Advanced JPS is said to be important for effective in increasing the success of the sports movement patterns of the need for accurate, high quality and an impressive implementation, as well as prevention and treatment of sports injuries (Yılmaz&Gök, 2006). Moreover, a proprioceptive insufficiency or deficit no matter how small it is can increase the risk of injury and mutilate balance, due to deformity in the posture. For a dancer even a small injury can prevent him/her from taking the right position of the movement. In case of undetection or undevelopment of the proprioceptive deficits, injuries may reoccur (Batson, 2009).

In conclusion, findings of this study revealed that professional Turkish classic ballet dancers had a significantly improved JPS related to shoulder and hip joints, probably due to long term dance education experience. Therefore, regardless of assessing a deficiency in JPS affecting the dance performance negatively, whether additional proprioceptive training sessions included in general dance training program lead to further improvements in JPS of professional ballet dancers should be investigated.

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