

SOME ANAEROBIC PERFORMANCE VARIATIONS FROM MORNING TO EVENING: MASSAGE AFFECTS PERFORMANCE AND DIURNAL VARIATION

ALGUMAS VARIAÇÕES DE DESEMPENHO ANAERÓBICO DA MANHÃ À NOITE: A MASSAGEM AFETA O DESEMPENHO E A VARIAÇÃO DIURNA

ALGUNAS VARIACIONES DE RENDIMIENTO ANAERÓBICO DE LA MAÑANA A LA NOCHE: EL MASAJE AFECTA EL RENDIMIENTO Y LA VARIACIÓN DIURNAL

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ABSTRACT: This study was conducted to determine the effects of massage on some anaerobic performance and diurnal variation. Twelve male athletes between the ages of 18-25, who exercised regularly for three days a week (age, 18.00± 2.17 years; height, 168.± 3.15 cm; 65± 2.63 kg; BMI 22.49±.44 years) participated in the study. While the non-massage protocol consisted of only 15 minutes of jogging (NM), the protocol with sports massage consisted of 5 minutes of jogging and 10 minutes of sports massage (SM). The protocols were applied in two time periods of the day (morning: 09.00-11.00, evening: 16.00-18.00). It has been reported that SM positively affects peak power and average power due to vertical jump performance compared to the NM protocol. In addition, it was determined that the SM protocol applied in the evening was more effective than SM protocol applied in the morning.

KEYWORDS: Diurnal variation. Sport massage. Vertical jump. Anaerobic power. Mean power.

RESUMO: Este estudo foi realizado para determinar os efeitos da massagem no desempenho anaeróbico e na variação diurna. Doze atletas do sexo masculino com idades entre 18-25 anos, que se exercitavam regularmente três dias por semana (idade, 18,00 ± 2,17 anos; altura, 168,1 ± 3,15 cm; 65 ± 2,63 kg; IMC 22,49 ± 0,44 anos) participaram do estudo. Enquanto o protocolo sem massagem consistia em apenas 15 minutos de corrida (NM), o protocolo com massagem esportiva consistia em 5 minutos de corrida e 10 minutos de massagem esportiva (SM). Os protocolos foram aplicados em dois períodos do dia (manhã: 09h00 às 11h00, tarde: 16h00 às 18h00). Foi relatado que SM afeta positivamente a potência de pico e a potência média devido ao desempenho do salto vertical em comparação com o protocolo NM. Além disso, determinou-se que o protocolo SM aplicado à noite foi mais eficaz do que o protocolo SM aplicado pela manhã.

PALAVRAS-CHAVE: Variação diurna. Massagem esportiva. Salto vertical. Potência anaeróbica. Potência média.

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RESUMEN: Este estudio se realizó para determinar los efectos del masaje sobre el rendimiento anaeróbico y la variación diurna. Doce atletas masculinos entre las edades de 18-25, que hacían ejercicio regularmente durante tres días a la semana (edad, $18,00 \pm 2,17$ años; altura, $168. \pm 3,15$ cm; $65 \pm 2,63$ kg; IMC $22,49 \pm 0,44$ años) participaron en la estudio. Mientras que el protocolo sin masaje consistió en solo 15 minutos de jogging (NM), el protocolo con masaje deportivo consistió en 5 minutos de jogging y 10 minutos de masaje deportivo (SM). Los protocolos se aplicaron en dos periodos del día (mañana: 09.00 a 11.00, tarde: 16.00 a 18.00). Se ha informado que SM afecta positivamente la potencia máxima y la potencia media debido al rendimiento del salto vertical en comparación con el protocolo NM. Además, se determinó que el protocolo SM aplicado por la noche fue más efectivo que el protocolo SM aplicado por la mañana.

PALABRAS CLAVE: Variación diurna. Masaje deportivo. Salto vertical. Potencia anaeróbica. Potencia media.

Introduction

In sports with anaerobic content, coordination, agility, balance, speed and power are the most important components (CRESPO; MILEY, 1998; ALTINKÖK; ÖLÇÜCÜ, 2012). Various methods have been developed to estimate anaerobic power as a result of exercises. Maximum accumulated oxygen deficit (MAOD) (HILL; DAVEY; STEVENS, 2002; LIMA, 2007), Wingate test (WAnT) (DOTAN; BAR-OR, 1983; BAR-OR, 1987; BENEKE *et al.*, 2002), maximum anaerobic running test (MART) (NUMMELA *et al.*, 1996), Margaria stair running test (NEDELJKOVIĆ *et al.*, 2007), vertical jump tests (NUMMELA, *et al.*, 1996) are some of these methods used to estimate this parameter. Especially in offensive and defensive situations in combat sports (ZANGELİDİS *et al.*, 2012; LIMA *et al.*, 2017) vertical jump has traditionally been used frequently to evaluate the power output of athletes and jump height has been accepted as an indicator of power output (MARKOVIĆ; JARIĆ, 2005; MARKOVIĆ; JARIĆ, 2007; YOUNG; CORMACK; CRICHTON, 2011). Judo, known as a Japanese martial art, needs short, fast, maximum power and strength during the match (FRANCHINI *et al.*, 2011; CHTOUROU *et al.*, 2013). Therefore, in addition to mental concentration, physical coordination, strength and agility performances should be at a high level in judo (KYLE, 2011). Vertical jump tests were frequently used to determine whether the power performance of judokas was at the maximum level (MONTEIRO *et al.*, 2011; LIMA *et al.*, 2017). For example, as a result of the vertical jump tests, it was stated that judokas had important indicators of strength and speed (PANOUTSAKOPOULOS *et al.*, 2016; LIMA *et al.*, 2017; KONS *et al.*, 2018). One of the factors in determining the anaerobic power indicators of athletes is to improve the current situation. For this reason, it has been

determined that different protocols are applied to improve anaerobic capacity. For example, MacDougall *et al.* (1977) stated that increases in ATP and PC storage following resistance training after a 5-month resistance training program (8-10 reps, 3-5 sets of elbow extension) may be beneficial in performances such as sprinting (MACDOUGALL *et al.*, 1977). In addition, improvements in anaerobic power occurred in individuals after a period of resistance training (SLADE *et al.*, 2003; CHROMIAK *et al.*, 2004), an increase in anaerobic capacity after 4th session in the training program consisting of 16 electromyostimulation (EMS) training sessions (30 min per session) (MIYAMOTO *et al.*, 2016). In addition to the training programs, one of the most important modalities that is thought to contribute to recovery and performance development is sports massage. Massage is applied rhythmically through pressure and stretching, defined as mechanical stimulation of tissues to aid acute preparation before performance (PRENTICE *et al.* 2004). It has also been widely used for therapeutic purposes in most cultures since past civilizations (CALLAGHAN, 1993; GOATS, 1994). Sports massage is used before exercise to improve exercise performance (ARROYO-MORALES *et al.*, 2011), to support the recovery of muscle performance and to reduce post-exercise fatigue (OGAÍ *et al.*, 2008). It has been reported that sports massage is effective in reducing perceived lower extremity fatigue and muscle stiffness and in restoring total strength during cycling ergometry (OGAÍ, *et al.*, 2008). In addition, it was observed that massage improved WAnT performance of athletes after the Wingate anaerobic cycle test (WAnT) (MICKLEWRIGHT *et al.*, 2005). It has been reported that the friction massage technique is more effective in removing lactic acid after anaerobic running compared to the non-massage group (TASKİN; BUDAK; SANIOĞLU, 2020). It has been stated that daily variation is effective in many physiological and behavioral variables in sports performance, and different results have been observed on daily variation (DESCHENES, *et al.* 1998; REILLY; GARRETT, 1998; RACINAIS *et al.*, 2005). Various mechanisms have been involved in achieving different results in daily variation on performance. Body temperature changes during the day were associated with physical performance differences observed in the afternoon compared to morning hours (KLİNE *et al.*, 2006) and it was determined that the maximum short-term performances reached the lowest values in the morning and maximum in the afternoon (SEDLIAK *et al.*, 2008; SOUÏSSÍ *et al.*, 2010). In addition, according to the results of the vertical jump tests, there is a 5-7% difference between the tests performed in the morning and evening (9:00 and 18:00) (BERNARD *et al.*, 1997), while the highest isometric grip strength is found at 14:00. It was observed between 19:00 (REILLY *et al.*, 2007). The existence of a daily performance variation was confirmed during only 1-3 first repetitions of

exercise during repeated short-duration high-intensity activities (RACINAIS *et al.*, 2005; HAMMOUDA, 2011; PULLINGER *et al.*, 2018). In addition, during 5×6 second bicycle sprints with a recovery period of 24 seconds, peak power values were found to be significantly higher in the afternoon (17:00) than in the morning (7:00) (CHTOUROU *et al.*, 2012).

Judo competitions are held in the morning and afternoon, and the athletes participating in the competition participate in several fighting competitions during the day. Therefore, it is important to investigate the studies that contribute to the daily performance changes of the athletes. Massage, which is widely used by athletes and thought to contribute to recovery performance, has different effects on performance improvement. In addition, it is observed that there are differences between the performance levels at different times of the day. From this point of view, it is seen that there is no study in the literature regarding the level of contribution of massage performed at different times of the day to performance development. This study was planned to determine the effects of massage on anaerobic performance and diurnal variation from morning to evening. The hypotheses of the study were determined to affect the vertical jump performance of the SM.

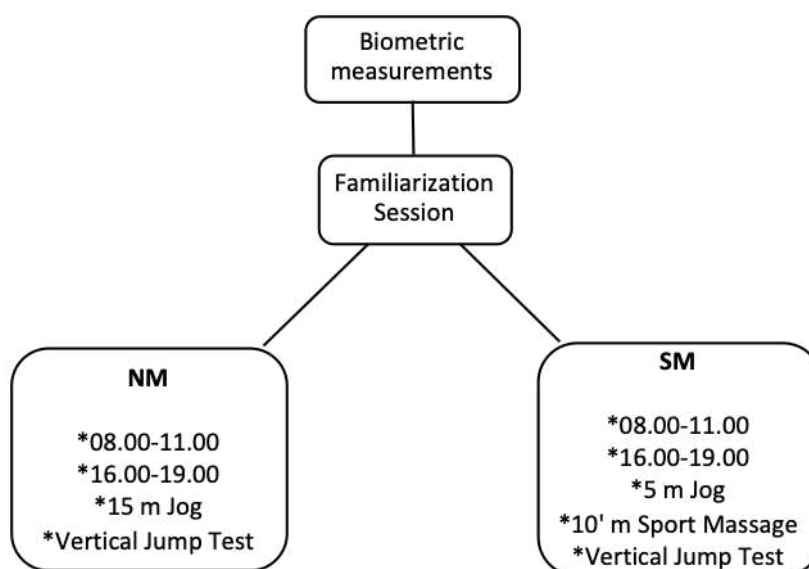
Method

Participants

Twelve male athletes between the ages of 18-25, who have been doing judo for at least 3 years, who exercise regularly for three days a week, participated in the study (age, 18.00 ± 2.17 years; height, $168. \pm 3.15$ cm; 65 ± 2 , 63 kg; BMI $22.49 \pm .44$). The criteria for inclusion of judokas in the research are (a) having been practicing judo for at least 3 years; (b) not have a history of disability that would affect the result of the study; (c) ensure regular participation in the study; (d) was determined as following the researchers' commands throughout the study. All judokas were given the necessary information about the requirements and risks related to the study and signed an informed consent form stating that they voluntarily participated in the study. The judokas participating in the study were given instructions on sleep and nutrition before the study and were asked to get at least six hours of sleep until the study day and to maintain their normal sleep habits. During the study, the athletes were asked to maintain their usual physical activity and refrain from strenuous activity for 24 hours prior to the study. They were also prohibited from consuming any stimulants (eg caffeine) or depressants (eg alcohol) prior to the study. Before starting the study, necessary approval was obtained from

the Malatya Inonu University Clinical Research Ethics Committee (Ethics Committee Protocol Number 2021/2616). Anaerobic performance measurements were taken from the judokas after different time periods of NM and SM (08.00-11.00, 16.00-19.00).

Figure 1 – Experimental flow diagram



Source: Prepared by the authors

Experimental Design of the Study

This study consists of a single group of twelve judokas. There is no control group in the study. In the study, the NM protocol was divided into morning (08.00-11.00) and evening (16.00-19.00). In addition, the SM protocol was divided into (08.00-11.00) and evening (16.00-19.00). A time interval of 72 hours was reported between the two different protocols (FOX, 2012). To exclude a cumulative effect, twelve judokas were recruited into two different massage protocols in random order. During the familiarization session, the judokas were informed about the protocols (NM, SM) and measurement times (08.00-11.00 in the morning and 16.00-19.00 in the evening). NM protocol consisted of 15 minutes of jogging; SM protocol consisted of 5 minutes of jogging and 10 minutes of sports massage. After the protocols, vertical jump measurements were taken from judokas and the average and peak anaerobic power performances of the judokas were determined according to Johnson & Bahomonde (1996) formula (JOHNSON; BAHAMONDE, 1996). This study continued for about 20 days with the familiarization session. Three attempts were made for the counter

movement jump test (Smart Jump; Fusion Sport, Australia). The highest value of the three trials for each variable was used for analysis.

Table 1 – Formulas for Johnson and Bahamonde estimated peak power and power averages (JOHNSON; BAHAMONDE, 1996).

Peak power (W) = 78.5 x VJ (cm) + 60.6 x mass (kg) -15.3 x height (cm) -1308
Average power (W) = 41.4 x VJ (cm) + 31.2 x mass (kg) -13.9 x height (cm) + 431

Source: Prepared by the authors

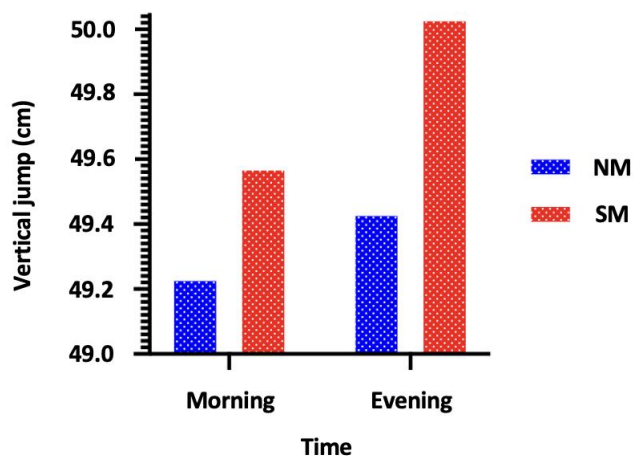
Sports Massage: After five minutes of jogging, the judokas were given 10-minute sports massage. Since judo competitions involve both upper and lower body muscle groups, massage treatments were applied to all body muscles for 10 minutes after the warm-up run (POCECCO *et al.*, 2012). The subject groups were massaged in the direction of the heart and muscle fibers by using eufluorage, friction, petrissage, and pressing applications, which are among the sports massage applications (WEERAPONG; HUME; KOLT, 2005; AÇAK; ÖNCÜ, 2006; JELVÉUS, 2011). In order to ensure consistency between the massage treatments applied to different athletes, all judokas were massaged by the same masseur. Aromatic oils, which affect the effect of massage, were not used especially in massage application.

Statistical analysis

Since the number of volunteers participating in the study was less than 50, the normality analyzes of the data were tested with the Shapiro Wilk's test. Paired Samples T-test was used to test the significance of the difference between the arithmetic means of two related groups. All statistical analyzes were performed with the IBM Statistics (SPSS, version 25.0, Armony, NY) package program. Data were expressed as mean±standard deviation ($\bar{x} \pm ss$) and significance level was accepted as $p < 0.05$.

Results

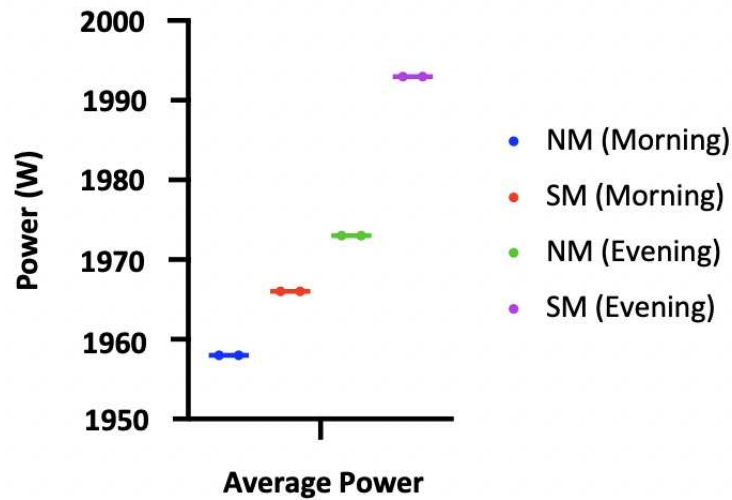
Figure 2 – NM and SM morning to evening vertical jump values



Source: Prepared by the authors

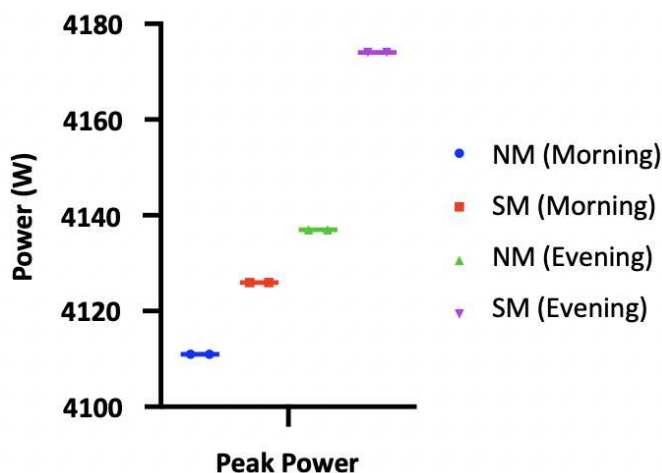
Figure 2 shows the comparison between NM and SM morning to evening vertical jump values. After NM (morning, 49.23 ± 3.12 ; evening, 49.57 ± 3.09) protocol, there was an increase in vertical jump values from morning to evening. After NM protocol, there was a statistically significant difference between the values of vertical jump from morning to evening ($t = -4.048$; $p < .002$). After SM (morning, 49.43 ± 2.83 ; evening, 50.03 ± 2.86) protocol, there was an increase in vertical jump values from morning to evening. After the SM protocol, there was a statistically significant difference between the values of vertical jump from morning to evening ($t = -4.681$; $p < .001$). However, when the protocols between NM and SM morning to evening vertical jump values were compared, it was determined that although there was a statistical difference, there was no statistical difference (NM and SM morning, $t = -1.016$; $p < .330$; NM and SM evening, $t = -1.794$; $p < .098$).

Figure 3 – Average power values of NM and SM from morning to evening



Source: Prepared by the authors

Figure 3 shows the comparison between NM and SM morning to evening average power values. After the NM (morning, 1957.69 ± 42.21 ; evening, 1972.62 ± 42.35) protocol, it was determined that there was an increase in the mean power values from morning to evening. After NM protocol, there was a statistically significant difference between the mean power values from morning to evening ($t = -4.042$; $p < .002$). After SM (morning, 1966.15 ± 38.49 ; evening, 1992.85 ± 38.23) protocol, it was determined that there was an increase in the mean power values from morning to evening. After the SM protocol, there was a statistically significant difference between the mean power values from morning to evening ($t = -4.646$; $p < .001$). However, when the protocols between NM and SM morning to evening mean power values were compared, it was determined that although there was a mathematical difference, there was no statistical difference (NM and SM morning, $t = -1.019$; $p < .328$; NM and SM evening, $t = -1.788$; $p < .099$).

Figure 4 – NM and SM peak power values from morning to evening

Source: Prepared by the authors

Figure 4 shows the comparison between NM and SM morning to evening peak power values. It was determined that there was an increase between morning to evening peak power values observed after NM (morning, 4110.85 ± 82.69 ; evening, 4137.46 ± 83.01) protocol. After NM protocol, there was a statistically significant difference between morning and evening peak power values ($t = -4.070$; $p < .002$). It was determined that there was an increase between morning and evening peak power values observed after SM (morning, 4125.85 ± 76.27 ; evening, 4173.77 ± 75.58) protocol. After SM protocol, there was a statistically significant difference between morning and evening peak power values ($t = -4.697$; $p < 0.001$). However, when the protocols between NM and SM peak power values from morning to evening were compared, it was determined that although there was a mathematical difference, there was no statistical difference (NM and SM morning, $t = -1.010$; $p < .333$; NM and SM evening, $t = -1.793$; $p < .098$).

Discussion

It is stated that the performances of the athletes during exercise or competition differ according to the time of exercise or competition. For this purpose, coaches or sports scientists are constantly working on the development of athlete performance. With the studies carried out, it is tried to determine the exercise protocols and time intervals in which athletes show the highest performance. It is thought that massage protocols applied before exercise or competition contribute to the performance development of athletes. However, the time intervals in which applied massage protocols contribute the most to performance development

have not been determined yet. It is considered important to determine the most appropriate protocol that contributes to performance development, especially in sports branches such as judo that require anaerobic performance, studies examining the effects of massage exercises that provide performance improvement before exercise or competition may add originality to the literature for judo athletes. The aim of our study is to evaluate the effects of massage on anaerobic performance and diurnal variation from morning to evening. From our hypotheses, it was determined that SM had a positive effect on peak power and power averages depending on the vertical jump performance compared to the NM protocol, and SM protocol applied in the evening was more effective than the SM protocol applied in the morning. In addition, the hypothesis that SM application applied at different time intervals could produce different results on peak power and average power values was also confirmed.

As a result of the literature review, it is the first study to compare the effects of massage on anaerobic performance and diurnal variation from morning to evening. According to the results of the study, it was determined that SM applied to the judokas in the evening had a positive effect on acute performance.

This is the first study to examine the effect of sports massage applied to judoka on anaerobic performance and diurnal variation. However, the findings are consistent with studies with similar characteristics examining the effects of anaerobic performance and diurnal variation. Studies in the literature including well-trained judoka (CHTOUROU *et al.*, 2013) and tennis players LÓPEZ-SAMANES *et al.*, 2017) reported that evening performances were significantly higher than in the morning. Hill and Smith (1991) measured anaerobic power and capacity in the morning and evening hours with a modified version of the Wingate test. It has been found that peak and average power outputs in the evening hours are higher than in the morning hours (HILL; SMITH, 1991). Reilly *et al.* (2007) reported a 10.7% performance decrease in the morning hours compared to the afternoon in the agility values applied using the dribbling test (REILLY *et al.*, 2007). Racinais (2005) evaluated leg strength using the repeated sprint ability test and found that the strength in the first sprint was 4.7% lower in the morning than in the afternoon (RACINAIS *et al.*, 2005). Souissi *et al.* (2004) reported that during the Wingate test, the peak and mean power fluctuated according to the time of day, reaching the lowest values in the morning ($7.6 \pm 0.8\%$) and peak values in the afternoon/evening ($11.3 \pm 1.1\%$) (SOUISSI *et al.*, 2004). Similarly, Chtourou *et al.* (2012) stated that during the Wingate test, peak power and mean power were higher in the evening ($3.1 \pm 3.6\%$) than in the morning ($2.9 \pm 3.5\%$) (CHTOUROU *et al.*, 2012). In addition, it has been stated in studies that the maximum short-term performances are reached with the lowest

values in the morning and maximum values in the afternoon (SEDLIAK *et al.*, 2008; SOUÏSSI *et al.*, 2010).

According to the findings, although it is consistent with studies with similar characteristics examining the effects of anaerobic performance and diurnal variation from morning to evening, it shows contradictory results with studies examining the effect of massage on performance. It has been stated that pre-performance massage has no effect on mood, but facilitates enhanced WAnT performance, and the relationship between massage and anaerobic performance remains unclear (MICKLEWRIGHT *et al.*, 2005). Kargarfard *et al.*, (2016) consisted of 30 male bodybuilders who were separated from the massage and control group. At the end of the study, the control group observed worsening vertical jump performance at 48 and 72 hours (KARGARFARD *et al.*, 2016). They also stated that the vertical jump performance of the massage group returned to the initial level at the 48th hour. It has been found that pre-exercise massage reduces muscle strength (WIKTORSSON-MOLLER, *et al.*, 1983) and has negative effects on vertical jump, speed and reaction time (ARABACI, 2008). The fact that the massage applied to increase sprint performance does not significantly benefit sprint performance (WALTERS, 2012), causes the effectiveness of pre-competition massage applications to be discussed (MORAN; HAUTH; RABENA, 2018). It has been reported that massage does not prevent speed performance, but massage can provide a psychological benefit for athletes (PEÑA *et al.*, 2014). Similarly, it has been found that sports massage is not harmful for flexibility or performance but can be used as a part of warming up (RICHMAN; TYO; NICKS, 2019). Considering individual factors, accompanied by scientific evidence, athletes should continue to use massage if it works (GWYNEE, 2012).

Conclusion

According to the results found in this study, it was determined that SM positively affected the peak power and mean power depending on the vertical jump performance compared to the NM protocol. In addition, it was determined that the SM protocol applied in the evening was more effective than the SM protocol applied in the morning. When evaluated from this point of view, sports scientists, coaches and athletes can contribute to performance increase if they include SM practice in their work. However, more in-depth and detailed studies are needed in order to obtain more precise results and to explain the contribution of SM application to performance. It is thought that determining the physiological mechanism of SM application will lead to future scientific studies.

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