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Effects of Percussive Therapy and Manual Massage on Pain, Range of Motion, Muscle Tension and Countermovement Jump Height After Acute Eccentric Exercise in Young Triathletes

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ORIGINAL ARTICLE

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Abstract

The purpose of this study was to investigate the effects of percussive therapy and manual massage applied to athletes following an eccentric exercise protocol on pain, range of motion, muscle tension, and vertical jump height. Male triathletes aged 15-18 years who trained regularly 6 days a week participated in the study. Participants were assigned to one of the following groups: control (CG), manual group (MG), and percussive group (PG). Athletes' baseline perceived pain score, muscle tension, ankle joint range of motion (ROM), and vertical jump height were measured at rest. A 6-day Alfredson eccentric exercise protocol was then applied to all 3 groups, and all measurements were repeated post-exercise. Manual massage following the Alfredson exercise protocol reduced perceived pain and muscle tension and increased joint range of motion. In athletes, percussive therapy following the Alfredson exercise protocol reduced perceived pain and increased vertical jump height and joint range of motion. In conclusion, both manual massage and percussive therapy are effective methods to eliminate the negative effects such as pain, limited range of motion, and increased muscle tension that may occur after eccentric exercise and can be recommended to triathletes in the post-training period.

Keywords: Manual Massage, Alfredson Protocol, Percussive Therapy, Muscle Tension.

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Genç Triatlonculardа Akut Eksantrik Egzersiz Sonrası Uygulanan Perküsif Terapi ve Manuel Masajın Ağrı, Eklem Hareket Açıklığı, Kas Gerginliği ve Dikey Sıçrama Yüksekliği Üzerine Etkisi

Öz

Çalışmanın amacı, sporculara eksantrik egzersiz protokolü uygulandıktan sonra uygulanan perküsif terapi ve manuel masajın ağrı, eklem hareket açıklığı, kas gerginliği ve dikey sıçrama yüksekliği üzerine etkilerini araştırmaktır. Çalışmaya haftada 6 gün düzenli antrenman yapan 15-18 yaş arası erkek triatloncular katıldı. Katılımcılardan kontrol (KG), manuel grup (MG) ve perküsif grup (PG) olmak üzere 3 grup olışturuldu. Sporcuların istirahatte bazal algılanan ağrı skoru, kas gerginliği, dikey sıçrama yüksekliği ve ayak bileği eklem hareket aralığı (ROM) ölçüldü. Daha sonra, 6 günlük Alfredson eksantrik egzersiz protokolü her 3 gruba da uygulandı ve tüm ölçümler egzersiz sonrası dönemde tekrarlandı. Alfredson egzersiz protokolünü takiben manuel masaj uygulaması, algılanan ağrı ve kas gerginliğini azalttı ve eklem hareket açıklığını artırdı. Sporcularda, Alfredson egzersiz protokolünden sonra perküsif terapi uygulaması, algılanan ağrı derecesini azalttı ve dikey sıçrama yüksekliği ile eklem hareket açıklığını artırdı. Sonuç olarak hem manuel masaj hem de perküsif terapi, eksantrik egzersizden sonra ortaya çıkabilecek ağrı, eklem hareket genişliğinde kısıtlılık, kas geriminde artış gibi olumsuz etkileri ortadan kaldırmada etkili yöntemlerdir ve triatlonculara antrenman sonrası dönemde önerilebilir.

Anahtar Kelimeler: Manuel Masaj, Alfredson Protokolü, Perküsif Terapi, Kas Gerginliği.

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Introduction

It is well-known that in addition to the training program, coping with the accumulated psychological and physiological stress factors caused by the mechanical loading is crucial for maximizing an athlete's performance capacity (Meeusen et al., 2013).

Eccentric contractions are contractions that increase intramuscular tension more significantly than concentric contractions. It has long been known that eccentric training, when performed under appropriate conditions, can significantly increase muscle strength (Doss and Karpovich, 1965). However, compared to isometric and concentric contractions, eccentric contractions are known to cause significantly greater muscle damage (Nosaka et al., 2002).

Recovering as quickly as possible after competition or training, and returning to pre-performance levels after fatigue, is considered a crucial element of success in almost every athletic discipline. Therefore, coaches, athletes, and athletic health and performance support teams are constantly searching for the most effective strategy to accelerate post-exercise recovery (Poppendieck et al., 2016).

During tight fixture schedules, recovery strategies are crucial for alleviating post-competition fatigue, allowing for faster performance recovery, reducing the risk of injury, and preventing recurrence of sports injuries. Fatigue following competition is multifactorial and primarily related to dehydration, glycogen depletion, muscle damage, and mental fatigue (Allen et al., 2008; Özdemir et al., 2013). Various subjective and objective methods are used to assess the level of muscular fatigue (Lau et al., 2013; Al-Nakhli et al., 2012; Bilgin et al., 2015). Furthermore, nutritional intake, cold water immersion, sleep, active recovery, stretching, compression garments, massage and massage guns, and electrical stimulation are among the most commonly used methods to reduce fatigue (Nédélec et al., 2013).

Sports massage, a manual therapy used to reduce muscle and soft tissue pain and increased tension, is widely used for recovery after intense exercise (Cortis et al., 2010; Davis et al., 2020). Farr et al. (2002) demonstrated that massage significantly aided in the relief of DOMS (Delayed Onset Muscle Soreness).

Unlike manual therapy, mechanical percussion devices can affect cutaneous and myofascial mechanoreceptors such as Ruffini receptors and Pacinian corpuscles. These receptors, which respond more strongly to high-frequency vibration or low-amplitude frequencies for longer periods (i.e., 15-60 minutes), can be stimulated more with devices designed for this purpose, helping to moderate sympathetic activity and, thus, producing more positive clinical outcomes. Considering the distribution of afferent receptors in the treatment area, it is quite reasonable to assume that manual

massage and percussion applied to different parts of the body may produce different effects. Existing literature studies focus primarily on the effects of percussive therapy devices on muscle activation and force output, while comparative studies on perceived pain, muscle tension, and joint range of motion are notable in their paucity (Germann et al. 2018). Therefore, we planned this study to comparatively present the effects of percussion therapy and manual massage on recovery parameters after eccentric exercise. Our hypothesis was that different applications would have different effects on recovery parameters. Therefore, the aim of this study is to investigate the effects of percussive therapy and manual massage on muscle tension, pain and joint range of motion levels by adding an eccentric exercise model to the training programs of athletes.

Materials and Methods

The study, conducted at Akdeniz University's Faculty of Sports Sciences. During the current research, the "Higher Education Institutions Scientific Research and Publication Ethics Directive" was followed.

Model of the Research

This study is an interventional experimental research based on quantitative research models (Büyüköztürk et al., 2024). In terms of experimental research models, it is a randomized controlled trial where participants are randomly selected, control and intervention groups are independently formed, and the obtained results are compared (Aksakoğlu G, 2001).

Population and Sample

A total of 30 national-level young athletes were planned to participate in the study, with 10 in each group. However, due to COVID-19 pandemic restrictions, the study could only be completed with 4 athletes in each group. The inclusion criteria for the study were that the athlete had no previous history of ankle or hamstring injury, was not taking any medication, trained regularly, and volunteered to participate. The exclusion criteria for the study were that the athlete had an injury, started using any medication, could not attend training regularly, and requested to leave the study voluntarily. All athletes were subject to the same training program and trained by the same coach. The athletes were randomly assigned to three groups: the control group, the percussive therapy group, and the manual therapy group. All triathletes trained with the same coach and standardized training program, were in the interseason, and their competition periods were identical.

All measurements were repeated for all athletes. Body composition measurements, active jump test, verbal pain score (VAS), muscle tension, joint range of motion (ROM), and physiological measurements were repeated before and after exercise. All participating athletes (age: 15.50 ± 2.07

years, height: 169 ± 7.87 cm, weight: 57.82 ± 9.23 kg) were informed about the study and randomly assigned to the manual massage, percussive therapy, and control groups.

Eccentric Exercise Application

The Alfredson protocol was used as an eccentric exercise model (Alfredson et al., 1998). This protocol targets the gastrocnemius and soleus muscles. The protocol was performed twice a day for six days, at the end of the athletes' morning and evening training routines. During this exercise, a physiotherapist checked the correctness of the exercise and adherence to the protocol. The athletes stood on a stair step with their toes pointing to the edge. Their heels hung over the edge of the step, holding onto something stable for balance, while both knees were straight. Using both feet, they lifted their heels and rose onto their toes. Using their ankles, they slowly lowered themselves down. Their heels moved toward the floor, and their toes remained in contact with the edge of the step. They performed this exercise for three sets of 15 repetitions. The exercise was performed with their knees straight, placing stress on the gastrocnemius muscle, which forms the Achilles tendon. The Alfredson protocol was then repeated with the knees slightly bent, applying pressure to the soleus muscle, which joins the Achilles tendon along with the gastrocnemius. Three sets of 15 repetitions were also performed. The two Alfredson protocol exercises were performed twice daily, morning and evening, for three sets of 15 straight knees and one with a bent knee, followed by a heel drop. A total daily exercise volume of 180 repetitions was achieved.

Interventions

Following the eccentric exercise applied to all three groups, the percussion group received percussion therapy for six days, and the manual massage group received manual massage for six days. The control group received no treatment.

Percussive therapy protocol

The device was applied using the Hypervolt device (Hyperice, California, US). A soft rounded attachment head was selected for this device, and a 53 Hz pulse was delivered. The same pressure was applied from distal to proximal, then distal again, and from medial to lateral with the same pressure (Konrad et al., 2020). The device offers three speed levels, and the second speed level was selected. In the study, percussive therapy was applied for 5 minutes after the second exercise protocol of the day for 6 days.

Manual Massage Protocol

With the athlete in the prone position, manual percussion techniques were applied by a licenced and well-trained personnel, moving from medial to lateral and distal to proximal, then

proximally again (Cheatham et al., 2021). In our study, manual therapy was applied for 5 minutes after the second exercise protocol of the day for six days.

Data Collection Tools

Anthropometric Measurements

Height

The athlete stood with bare feet on a flat surface at a right angle to the wall scale. The subject's weight was distributed equally between both feet, with heels together and touching the wall scale, the head in a Frankfort plane, and the arms hanging freely at the shoulders. During the measurement, the participant was asked to take a deep breath and maintain an upright position without leaving the heels off the floor. The hair was sufficiently pinched at the crown of the head, and the measurement was recorded to the nearest 1 mm (Özer, 1993).

Body Weight

Participants were placed on a scale wearing undershirts and shorts, and measurements were taken. Values were recorded in kilograms (kg) (Özer, 1993).

Body Fat Percentage, Body Mass Index (BMI) and Muscle Mass

Determined by the bioelectrical impedance method (Tanita body cosmoposition analyzer TBF-300).

Counter Movement Jump Test

Measurements were performed before and after the Alfredson protocol using a force plate device and software (ForceDecks, Vald Performance Pty Ltd., Brisbane, Australia). From a standing position with feet shoulder-width apart, the patient moved downward with flexion of the knee and hip joints to a free squat position. Afterward, a rapid, fluid, and maximal upward pre-tension contraction cycle was performed without pause (Kaçoğlu and Yıldırım, 2017). Each jump test was performed in three repetitions with one-minute rest intervals, and participants were asked to jump to their maximum height. The average of the obtained values was recorded for analysis.

Verbal Pain Score (VAS)

A 10-point pain score was used to assess the severity of pain observed before and after the Alfredson protocol. Accordingly, a score of 0 represented no pain, and a score of 10 represented unbearable pain.

Muscle Tension Assessment

Assessed using manual palpation. A 5-point rating scale was used to assess muscle tension. A score of 0 indicates no tension, and a score of 5 indicates excessive tension.

Joint Range of Motion (ROM) Measurement

Joint range of motion was measured using a goniometer. The ankle joint range of motion was measured in dorsiflexion and plantarflexion, with the axis of rotation between the goniometer arms aligned with the joint axis (pivot point), and the goniometer arms aligned with the joint arms.

Physiological Measurements

The heart rate and blood pressure values of the athletes were measured before and after the exercise session using an electronic sphygmomanometer (Omron, RS 2).

Analysis of Data

The study results were analyzed using the statistical program "Statistical Package for Social Sciences" (SPSS) Version 23.0 (SPSS Inc., Chicago, IL, USA). The Shapiro-Wilk test was used to test the data for normal distribution. The Mann-Whitney U test was used for comparisons between groups because the data did not conform to a normal distribution. The Wilcoxon Test was used for pre- and post-test comparisons of the groups. The p value of less than 0.05 was considered significant.

Ethics of Research

The study was approved by the Akdeniz University Clinical Research Ethics Committee (Decision No: KAEK-750) and was conducted in accordance with the Declaration of Helsinki. In the study, informed consent forms were signed by the legal guardians of the athletes.

Results

Physical characteristics of the athletes

The physical characteristics of the athletes included in the study, including age, height, body mass, body mass index, and body fat percentage, are presented in Table 4.1. Accordingly, the body fat percentage in the Percussive Group was found to be higher than the Manual Group ($p<0.021$).

Table 1
Physical Characteristics of the Triathletes

Parameter	Control group	Manual group	Percusive group

Age (yr)	15,25 ± 1,71	17,25 ± 2,22	14,00 ± 0,82
Height (m)	166,75 ± 7,85	172 ± 4,55	169,50 ± 11,24
Body mass (kg)	57,17 ± 6.82	59.75 ±10.95	56.52±11.74
Body mass index ($kg.m^{-2}$)	20.57 ± 20,09	20,10 ± 2,65	19,47 ± 1,50
Body fat (%)	17,87 ± 5,95	10,07 ± 0,98	13,85 ± 1,72#

#p<0.05, difference from the Manual group.

Physiological measurements of the athletes

The average pre- and post-test physiological measurement results of the athletes are presented in Table 2. Accordingly, the pre-test systolic blood pressure in the Manual Group was found to be higher than the Control Group (p<0.028). The post-test systolic blood pressure in the Manual Group was also found to be higher than the Control Group (p<0.032). Conversely, the post-test systolic blood pressure in the Percussion Group was found to be higher than the Control Group (p<0.036). In the intragroup comparison of the Percussion Group, the post-test systolic blood pressure measurement was found to be higher than the pre-test measurement (p<0.046).

Table 2
Pre- and Post-Test Heart Rate and Blood Pressure Results of the Athletes

	Parameter	Control group	Manual group	Percusive group
Pre-test	**Heart rate (min^{-1})**	84,25 ± 11,44	83,75 ± 18,0	76,50 ± 16,52
	Systolic blood pressure (mmHg)	90,00 ± 8,16	115,00 ± 12,90 *	100,00 ± 8,16
	Diastolic blood pressure (mmHg)	55,00 ± 10,00	60,00 ± 8,16	62,50 ± 9,57
Post-test	**Heart rate (min^{-1})**	84,75 ± 9,50	84,50 ± 11,82	80,25 ± 9,64
	Systolic blood pressure (mmHg)	95,00 ± 5,77	115,00 ± 10,00 *	110,00 ± 8,16 †*
	Diastolic blood pressure (mmHg)	55,00 ± 5,77	62,50 ± 12,58	62,50 ± 9,57

*p<0.05, difference from the Control group, †p<0.05, difference from pre-test measurement.

Counter Movement Jump Height Measurements of the Athletes

The pre- and post-exercise average vertical jump height results for each group are presented in Table 3. Accordingly, the pre-test vertical jump height of the Manual Group was found to be higher than that of the Control Group (p<0.021). Conversely, the post-test vertical jump height of the Percussive Group was found to be higher than that of the Control Group (p<0.043).

Table 3

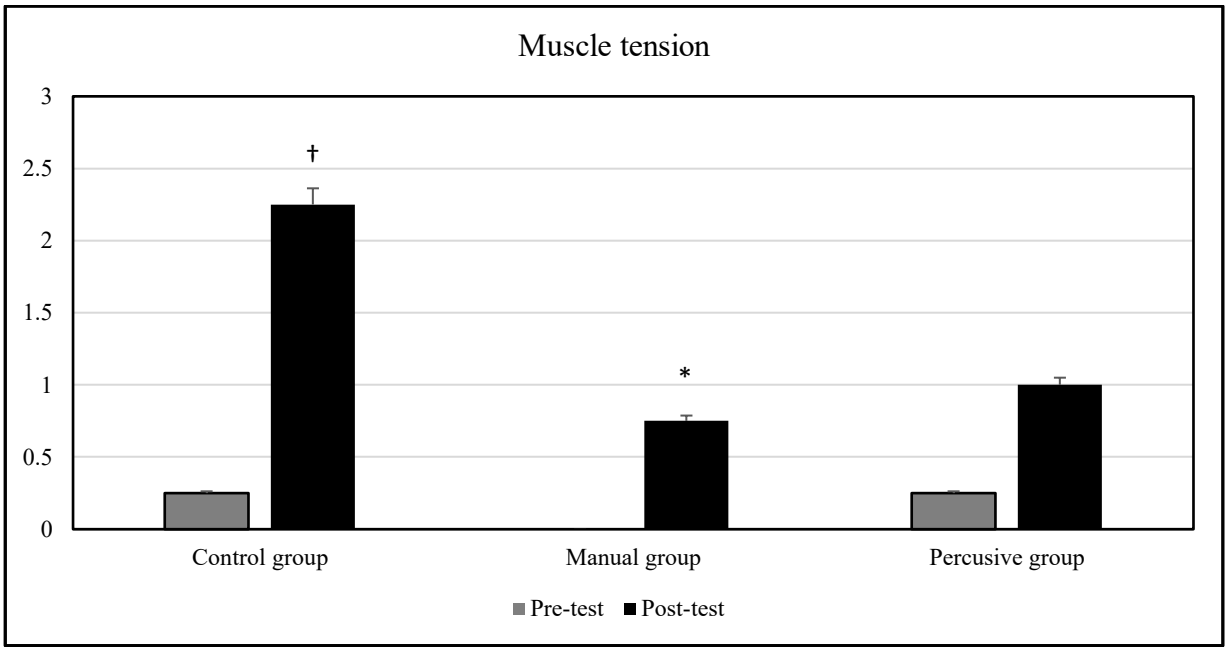
Pre- and Post-Test Vertical Jump Height Results of the Athletes (cm)

	Control group	Manual group	Percusive group
Pre-test	24,24 ± 3,88	33,80 ± 4,45 *	35,02 ± 6,43
Post-test	26,97 ± 5,02	34,16 ± 4,16	34,58 ± 5,24*

*p<0.05, difference from the Control group

Muscle tension measurement of the athletes

The pre- and post-test mean muscle tension results for the groups are presented in Figure 1. Accordingly, the post-test muscle tension in the Control Group was found to be higher than the pre-test (p<0.046). Conversely, the post-test muscle tension in the Control Group was found to be higher than the Manual Group (p<0.015).



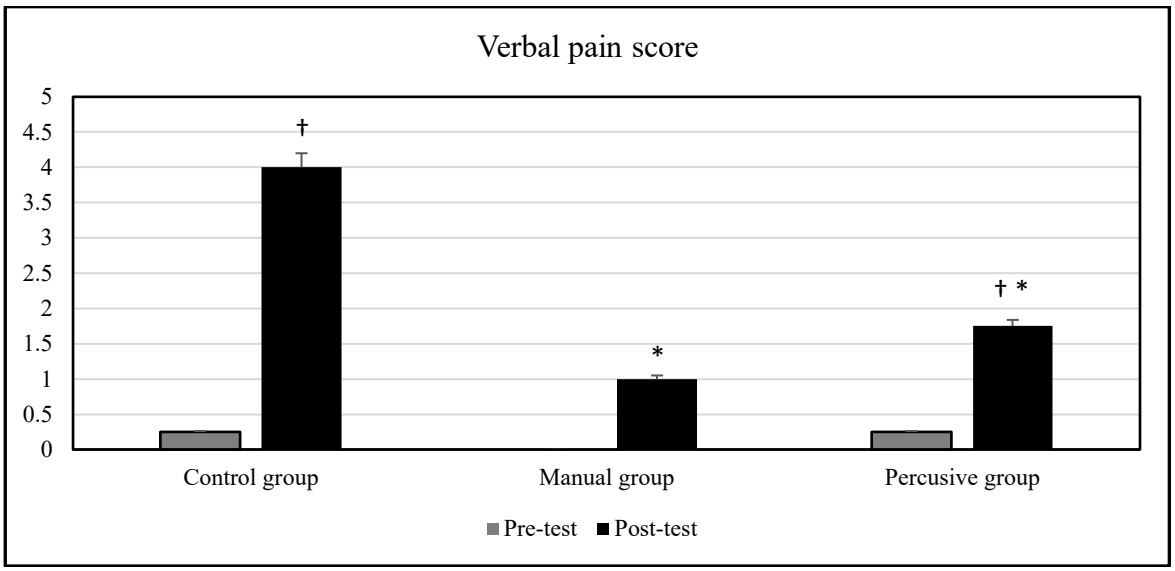
*p<0.05, difference from the Control Group, †p<0.05, difference from pre-test measurement.

Figure 1. Muscle tension measurement results of the study groups (g) (Mean+SD)

Verbal Pain Score Measurements of Athletes

The mean verbal pain scores for the pre- and post-test measurements of the groups are presented in Figure 2. Accordingly, the Control Group had a higher verbal pain score in the post-test measurement compared to the pre-test measurement (p<0.046). The Manual Group had a lower verbal pain score in the post-test measurement compared to the Control Group (p<0.019). On the other hand, the Percussion Group had a higher verbal pain score in the post-test measurement compared to the

pre-test measurement (p<0.046). The Percussion Group had a lower verbal pain score in the post-test measurement compared to the Control Group (p<0.017).



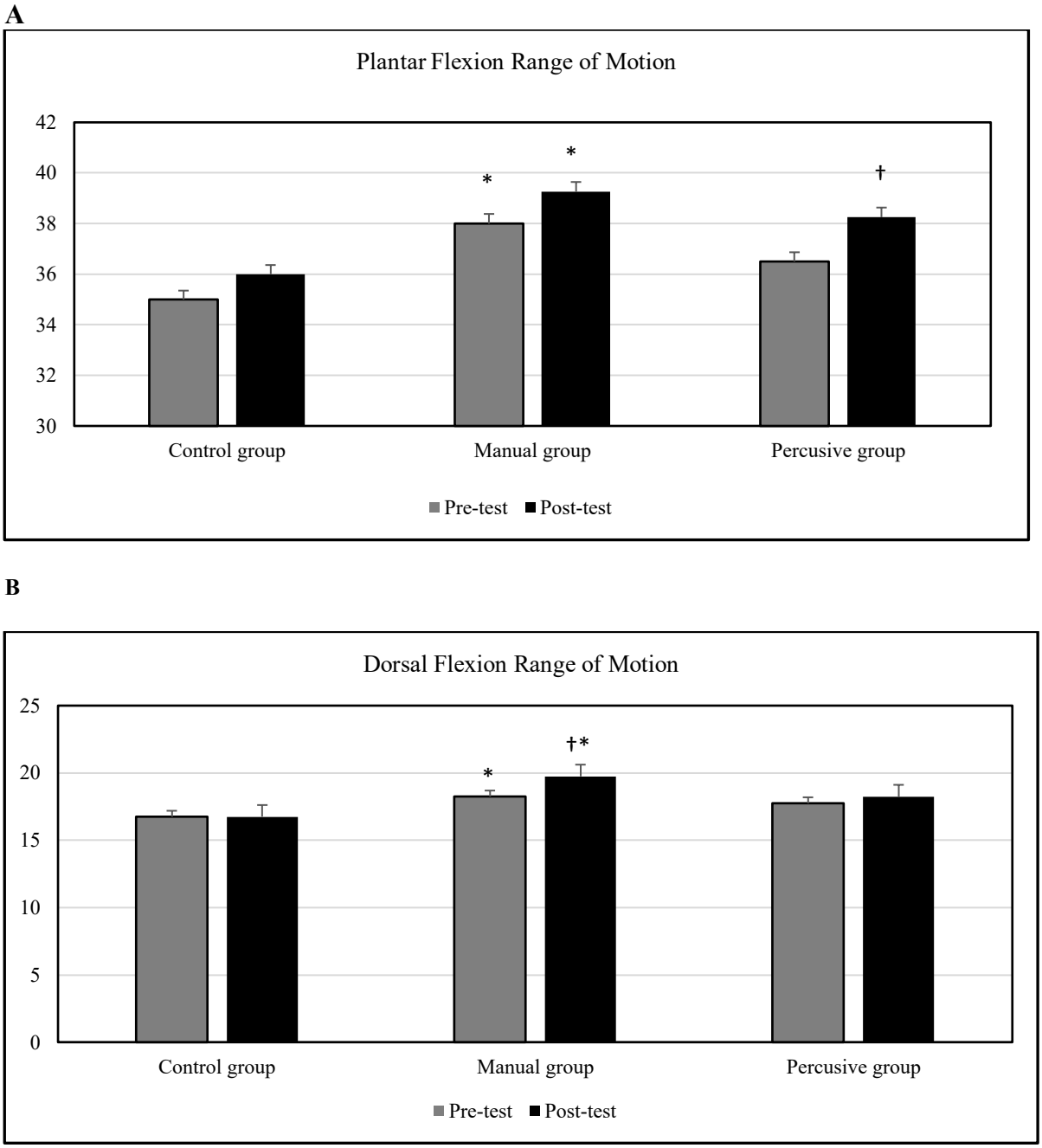
*p<0.05, difference from the Control group, †p<0.05, difference from pre-test measurement.

Figure 2. Verbal pain score results of the study groups (mean+SD)

Joint Range of Motion (ROM) Measurements of the athletes

Pre- and post-test mean plantar joint range of motion results for the groups are presented in Figure 3A. Accordingly, the pre-test plantar joint range of motion in the Manual Group was found to be greater than the Control Group (p<0.019). Furthermore, the post-test plantar joint range of motion in the Manual Group was found to be greater than the Control Group (p<0.027). Furthermore, in the intra-group comparison of the Percussive Group, the post-test plantar joint range of motion was found to be greater than the initial measurement (p<0.046).

Pre- and post-test mean dorsal joint range of motion results for the groups are presented in Figure 3B. Accordingly, in the intra-group comparison, the post-test dorsal joint range of motion in the Manual Group was found to be greater than the pre-test measurement (p<0.046). Furthermore, the pre-test dorsal joint range of motion in the Manual Group was found to be greater than the Control Group (p<0.044). In addition, it was determined that the post-test dorsal joint range of motion of the Manual group was higher than the Control Group (p<0.017).



*p<0.05, difference from the Control group, †p<0.05, difference from pre-test measurement.

Figure 3. Ankle range of motion results during plantar (A), or dorsal (B) flexion of the study groups (˚)

Discussion and Conclusion, Suggestions

The aim of this study was to determine the effects of manual massage and percussive therapy methods applied after a 6-day eccentric exercise protocol on muscle pain, tension, and joint range of motion. The study findings revealed that both percussive therapy and manual massage had positive effects on these parameters.

In the study, systolic blood pressure was higher in both the Percussive and Manual Groups after the exercise session compared to the Control Group. In contrast to this study, a 2023 study by

Sifaq et al. (2023) showed that sports massage reduced systolic blood pressure and diastolic blood pressure. The reason for these different results may be that, while the study by Sifaq et al. (2023) extended the massage area to all extremities for up to 62 minutes, our study included only the gastrocnemius and soleus regions and was limited to 5 minutes.

In the present study, the verbal pain score was found to be higher in the Percussion Group at the final measurement compared to the initial measurement, but lower than in the Control Group. In the within-group comparison of the Percussion Group, the final plantar joint range of motion was found to be higher than the initial measurement. Furthermore, the final vertical jump height in the Percussion Group was found to be higher than in the Control Group. In a previous study, we demonstrated the positive effect of massage on the hypoalgesic response induced by eccentric exercise (Kaplan et al., 2014). In this study, we found results consistent with the findings of a meta-analysis of 39 studies by Martin and colleagues, which indicated that percussion therapy reduced perceived muscle soreness and increased joint range of motion (Martin et al., 2021). Although manual massage was more effective than percussion therapy in reducing perceived pain, preventing muscle tension, and increasing joint range of motion, the positive effect of percussion therapy on vertical jump height, unlike manual massage, is noteworthy. Therefore, we believe that recommending the use of both methods for triathletes would be a more logical approach.

In triathletes, overtraining is the leading cause of injury at 43.1%, with most injuries occurring primarily in the lower extremities (Minghelli et al., 1992). Furthermore, because the risk of injury in triathletes is thought to increase with age, this study group consisted of young triathletes who had been training twice a week for at least 4 years. The participating athletes had very similar characteristics in terms of selection criteria and were preparing for national-level competitions. Therefore, we believe it is important to consider the findings in training programs for older athletes.

Alfredson eccentric exercise, which involves high-intensity calf muscle movement, can be used for therapeutic purposes in addition to increasing muscle strength. It is an effective method for the pain management of Achilles tendinosis (Alfredson et al., 1998). Another study by Van der Plas et al. (2012) also supported the study conducted by Alfredson et al. (1998). According to this study, in a 5-year follow-up study of 58 patients (70 tendons) with chronic mid-portion Achilles tendinopathy, the Alfredson heel drop eccentric exercise program showed complete pain relief in 39.7% of patients, and sagittal tendon thickness decreased from 8.05 mm (SD 2.1) at baseline to 7.50 mm (SD 1.6) (Van der Plas et al., 2012). Unlike our study, these studies were performed on patients, and Alfredson exercise was also used for treatment. In this study, we selected healthy individuals and athletes and completed the daily exercise volume of 180 repetitions in the Alfredson exercise protocol to induce exercise-induced muscle damage.

This study has limitations such as the small number of participants, the inclusion of only young male athletes, the limitation of the applied eccentric exercise model to 6 days, and the acute application of manual and percussive therapy. While these factors may make it difficult to generalize the study results, we believe that the fact that the participants were national-level athletes will contribute to practitioners working with elite-level athletes in the field and increase the value of the results obtained.

In conclusion, this study demonstrated that manual massage following the Alfredson exercise protocol in triathletes reduced muscle tension, perceived pain, and improved joint flexibility in the dorsiflexion direction. Percussion therapy, on the other hand, was found to increase range of motion, reduce perceived pain, increase range of motion in the plantar flexion direction, and increase vertical jump height. Positive effects were observed on pain, muscle tension, and range of motion in triathletes.

Considering the effects of reducing muscle tension, increasing range of motion, relieving perceived pain, and increasing vertical jump height in triathletes, we recommend the regular inclusion of both manual massage and percussion therapy in training programs following the Alfredson exercise protocol.

Ethics Committee Approval Information

Ethics Committee: Clinical Research Ethics Committee of Akdeniz University Faculty of Medicine

Date of approval: 19 December 2022

Approval number: 716

Author Contributions

Both authors contributed equally to all stages of the study.

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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