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ORIGINAL

DEEP DRY NEEDLING ENHANCES JUMP PERFORMANCE IN ELITE BEACH VOLLEYBALL PLAYERS

LA PUNCIÓN SECA AUMENTA EL RENDIMIENTO DE SALTO EN JUGADORES ÉLITE DE VÓLEY PLAYA

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ABSTRACT

The present study aims to assess whether Deep Dry Needling in latent Myofascial Trigger Points is associated with changes in jumping performance. Six Under-21 international beach volleyball players received intervention in vastus lateralis and medialis of the quadriceps. Three squat jump (SJ) and countermovement jump (CMJ) heights were measured in four sessions: pre- and post-intervention (acute effect), 48 h and 7 days after intervention (long-term effects). The players showed a small decrease after the intervention followed by a non-significant increase at 48 h. However, both jump types resulted in very likely moderate increase after one week of intervention: 4.13 cm (+10.8%) and 3.54 cm (+8.9%) for SJ and CMJ, respectively (3 times the smallest worthwhile change). Despite this significant increase, the decreased performance in post-test results discourages practitioners from using this technique just before a competition.

KEYWORDS: Myofascial Trigger Points; Long-term effects; Intervention, Muscle, Magnitude Based Inference, MBI

RESUMEN

El objetivo del presente estudio es evaluar si la aplicación de la punción seca en los puntos gatillo miofasciales latentes se asocia con cambios en el rendimiento de salto. Seis jugadores internacionales de los diez que forman el equipo nacional de vóley playa sub 21 recibieron tratamiento en el vasto lateral y medial de los cuádriceps. Se midieron tres pruebas de salto SJ y CMJ en cuatro sesiones: antes y después de la intervención (efecto agudo), 48 h y 7 días tras la intervención (efectos a largo plazo). Los jugadores mostraron una pequeña disminución post-intervención seguida de un aumento no significativo a las 48h en los valores de altura de salto registrados. Sin embargo, ambos tipos de salto dieron lugar a un aumento en la altura de salto con efecto moderado muy probable después de una semana de la intervención: 4,13 cm (+10,8%) y 3,54 cm (+8,9%) para SJ y CMJ, respectivamente. A pesar de este aumento significativo, la disminución del rendimiento posterior a la prueba desalienta su uso justo antes de una competición.

PALABRAS CLAVE: puntos gatillo miofasciales; efectos a largo plazo; intervención, músculo, inferencia basada en magnitudes, MBI

INTRODUCTION

Beach volleyball is a sport modeled by a number of external factors such as environmental conditions, playing surface or air temperature and also by specific game rules which can condition the performance of athletes (Jimenez-Olmedo & Penichet-Tomas 2017). This is a sport where some specific performance indicators are directly related to the success of the match. For instance, the number of points won in each game, the relation between points and errors by game actions, and the coefficient of game actions performance allows for explaining the factors between winning and losing in beach volleyball matches (Medeiros et al. 2017). With regards to internal factors, the physical demands of beach volleyball are age-related and therefore, elite level demands cannot be extrapolated to the rest of lower levels. Researchers have reported an increase in the demands of the game regarding differences in relation to the temporal variables of the game and physical variables as a function of the age of athletes (Medeiros, Marcelino, Mesquita, & Palao, 2014).

On the other hand, of the different technical elements that exist and must be developed by athletes, jumping is the most important technical action in beach volleyball, since it is directly related to performance and fitness. In addition, jumping is especially important in this sport, as it is performed in combination with other decisive technical actions such as serve, block, spike, and shot. Jump execution is determined by the athlete's physical ability and coordination on the playing surface and has become a key skill in beach volleyball

performance. Several factors can affect the athlete's ability to jump by reducing muscle flexibility and strength: muscle injuries like muscle tightness or previous muscle injuries, age, ethnicity, strength imbalances, reduced flexibility, fatigue, knee injuries, or high BMI. Among these factors, Myofascial Trigger Points (MTrPs) have been reported to show a negative influence on the correct functioning of the motor activity. MTrPs can be active, causing spontaneous pain and being painful upon palpation or latent, which are only painful to palpation with no spontaneous pain (Hsieh, Yang, Liu, Chou, & Hong, 2014). Three major interventions can be established for an effective treatment for MTrPs: a) Clinician or patient-administered manual therapy like passive rhythmic release, active rhythmic release, or trigger-point pressure release; b) Clinician-administered manual therapy like spray and stretch; c) Needle therapy like dry needling or injections (Simons 2004). The latter intervention has usually been applied for the treatment of pain in different regions of the body (Liu et al. 2018), as well as for the rehabilitation of dysfunctional areas (Rainey 2013; Cross & McMurray 2017).

Recently, dry needling has been started to use in the treatment and recovery of athletes, such as volleyball athletes with acute shoulder injuries during competitive periods with high intensity and training load, who reported short-term pain relief and improved active shoulder ROM after treatment (Osborne & Gatt, 2010). Further, the acute effect of dry needling treatment has also been studied on a chronic golfer's elbow disability reporting an improvement in the athlete's physical performance within 48 hours of treatment (Shariat et al. 2018). Researchers have also demonstrated that a combination of dry needling with specific strength training can help athletes to recover and improve hamstring strain (Dembowski, Westrick, Zylstra, & Johnson, 2013). Although dry needling is a treatment with positive effects on pain relief, the effect on sports performance is still relatively unexplored. Some studies have found an increase in jump height only after the intervention (Bandy, Nelson, & Beamer, 2017), after the intervention and 48 hours later (Devereux, O'Rourke, Byrne, Byrne, & Kinsella, 2018), while others have not been able to identify clinically significant improvements in the intervention (Geist et al., 2017).

However, no studies have attempted to analyze the acute and long-term effect of this type of treatment on athletes' performance. Therefore, the aim of the present study was to assess whether Deep Dry Needling (DDN) in latent MTrPs of the vastus lateralis and medialis is associated with changes in jumping performance in Under-21 international Beach Volleyball players.

METHOD

SUBJECTS

This study performed uncontrolled clinical trials with six Under-21 (2 blockers and 4 diggers) international male beach volleyball players. All participants were specialist beach volleyball players (not playing in related disciplines like indoor volleyball) with a minimum training experience of 4 years (body mass: 75.3 ± 11.3 kg, height: 184.7 ± 7.8 cm, and body mass index: 21.8 ± 2.1 kg/m²). They performed weekly specific training consisting of 9 hours in the gym and 14

hours in the sand, consisting of combined technical and tactical aspects with specific training exercises of power, jump, speed, and agility.

DATA COLLECTION

Jump heights were collected with a validated open-source jump-map system (Chronojump Boscosystem, Barcelona, Spain), which comprises a rigid platform connected to a computer via a tailored signal adapter (Pueo, Lipinska, Jiménez-Olmedo, Zmijewski, & Hopkins, 2017). The jump-mat registered flight times (t) with a temporal resolution of 1 ms and used the kinematic equation $h=t^2 \cdot g/8$ in order to compute jump height h , where g is the gravity acceleration (9.81 m/s^2). For the dry needling intervention, specific surgical steel physiotherapy needles, sized 0.30 mm x 50 mm, were employed (Agupunt, Barcelona, Spain). The intervention was made following specific protocols (Hong & Simons 1998).

PROCEDURES

A prospective longitudinal study design was conducted with elite players in a single experimental group. Given the population of under 21 elite beach volleyball players at the national level and the type of invasive intervention they received, it was decided to apply an intervention in a pre-time series and several post sessions to a unique experimental group of 6 players. A controlled trial was logistically difficult as the number of subjects per group would have been very low. To assess the effect of deep dry needling, the following specific protocol was performed. First, participants were selected following these criteria: beach volleyball players must be part of specific beach volleyball training programs and they must show clinical features of myofascial trigger points (MTrPs). Players who showed any of the following situations were excluded from the study: spontaneous lower limb pain, unsurmountable fear of needles, blood coagulation alterations, and lack of player agreement. A diagnostic physical examination was performed to identify myofascial trigger points (MTrPs) by means of four manifestations (Simons 2004): a) Taud band; b) Focal sport muscle tenderness; c) Pressure-elicited referred pain pattern; d) If active, pressure elicits symptoms recognized as familiar.

All selected athletes were informed about the experimental protocol and procedures of the study and they were also given written informed consent that they voluntarily signed. The Ethics Committee at the University of Alicante gave institutional approval to this study, in accordance with the Declaration of Helsinki (IRB UA-2018-10-16).

The vertical jump test consisted of jump height measurements in four sessions: pre- and post-intervention to account for acute effects of treatment, and 48 h and 7 days after interventions to look into long-term effects. Specifically, each athlete performed trials of squat jump (SJ) and countermovement jump (CMJ) tests in a jump mat system. Squat Jump started with knees bent at 90° and with hands on hips to avoid the arm contribution to the jump. Countermovement jumps started with hands on hips from standing position allowing for countermovement up to 90° knee bending followed by jump (Sánchez-Sixto,

Harrison, & Floría, 2019). Athletes performed three trials of each jump, and the best one was employed for statistical analysis. To avoid muscle fatigue, 2-minute rest time between the 3 repetitions of SJ, followed by a 5-minute rest time before starting the series of CMJ jumps. SJ and CMJ trials showed ICC values of 0.95 and 0.96, and CV values of 4.2% and 2.9%, respectively, which demonstrated consistency in athletes' performance.

The dry needling intervention was carried out the first day after baseline jump measures (pre-intervention). After leaving a complete rest of 5 minutes, the athletes were intervened with dry needling. Beach volleyball athletes were placed in a supine decubitus position with the quadriceps in relaxation. After detecting the trigger point, the area to be punctured was disinfected with antiseptic. Then, 20 insertions maximum and 2 local twitch responses (LTRs) of deep dry needling in MTrP in vast lateral and medial of the quadriceps were performed by a professional physiotherapist with six-year experience, followed by compression for 30 seconds over the treated area. The vast medial and the vast lateral were selected to perform the intervention since these two muscle heads produce twice as potential's action than any other part of the quadriceps (Hong & Simons, 1998).

After a 10-minute rest after the intervention, a jump assessment was carried out again as a post-test. Finally, to evaluate the effect of the dry needling intervention, the jump protocol described above was repeated 48h after the dry needling intervention and 7 days later.

DATA ANALYSIS

Mean and standard deviation values were used for descriptive analysis. The Kolmogorov-Smirnov test was performed to test for normal distribution. Pre- and post-intervention, 48 hours and 7 days comparisons of the jump heights were performed using the paired samples *t*-test. Values of $p < 0.05$ were considered to indicate statistical significance. To test the stability of the athlete's performance, the coefficient of variation (CV) and Intraclass Correlation Coefficient (ICC) were used. Contrast results were interpreted using both the modified Cohen's *d* (Hedges), where 0.2, 0.5 and 0.8 stands for small, moderate and large, respectively, and also by means of magnitude-based inference (MBI), where < 0.1 , 0.2, 0.6 and 1.2 stands for trivial, small, moderate and large, respectively (Hopkins, Marshall, Batterham, & Hanin, 2009). MBI is based on 90% confidence intervals (CI) that represent the uncertainty in the true value of the jump improvement. Three scales can be defined according to the minimum improvement likely to have a practical impact, also known as the smallest worthwhile change (SWC): substantially positive, trivial, and substantially negative (Buchheit, 2016). Chances that the true values lay on these scales are calculated by comparison with CI: if the chance that the true values do not overlap positive and negative ranges substantially, then the magnitude of the observed value is estimated with the following probabilistic terms: possibly, 25-75%; likely, 75-95%; very likely, 95-99.5% and most likely, $> 99.5\%$. The SWC to look for meaningful jump height variations has been set up to 20% of between-sessions pooled SD. An available spreadsheet (Hopkins, 2007) was used to calculate mechanistic inferences and, confident limits.

All vertical jump heights during post-test, after 48 hours, and after 7 days were compared to baseline values during pre-test. Meaningful differences were identified when mean values were lower or higher than SWC (depicted in grey area in plots) and when their limits of 95% confidence intervals (CI) did not intersect SWC area, representing trivial changes.

RESULTS

For the first jump type (SJ), the pre-test jump height mean value before intervention was 38.15 cm, considering as a baseline to which compare the rest of jump heights, as shown in Table 1. Just after intervention, there was a likely decrease in jump height of 1.75 cm (-4.58%), which can be due to the post-intervention pain in the treated muscle. After 48 hours, there was a slight improvement of 1.80 cm (+4.71%), although possibly trivial, which suggest that athletes have reached similar values to pre-test. Finally, a possibly large improvement of 4.13 cm (+10.82%) was observed in the evaluation carried out after 7 days.

Table 1. Average jump performance across the different sessions, along with mean difference, magnitude-based inferences (MBI), and Cohen's corrected effect size for changes in jump height from pre-test values. [95% CI] is indicated where appropriate.

Jump	Variable	Pre-test	Post-test	48 h	7 days
SJ	Jump height (cm)	38.15 [36.08 – 40.89]	36.40 [34.33 – 38.12]	39.95 [35.15 – 44.97]	42.28 [39.25 – 45.38]
	Mean difference (cm)		-1.75 [-2.90 – -0.60]	1.80 [-1.86 – 5.46]	4.13 [2.57 – 5.69]
	Mean difference (%)		-4.58	4.71	10.82
	MBI		Small**	Trivial*	Moderate***
	<i>d</i>		0.64 [-1.91 – 2.62]	0.39 [-4.73 – 2.93]	0.89 [-4.23 – 3.44]
	ES			Moderate	Small
CMJ	Jump height (cm)	39.58 [37.32 – 41.67]	38.78 [36.67 – 40.56]	40.33 [35.89 – 44.88]	43.12 [39.98 – 46.09]
	Mean difference (cm)		-0.79 [-1.52 – -0.06]	+0.75 [-2.81 – 4.30]	+3.54 [1.95 – 5.13]
	Mean difference (%)		-2.02	1.89	8.94
	MBI		Small*	Trivial**	Moderate***
	<i>d</i>		0.32 [-1.97 – 2.37]	0.18 [-4.53 – 2.47]	1.12 [-2.04 – 3.41]
	ES			Small	Trivial

95% CI: confidence intervals, Limits of Cohen's *d* scale and MBI: <0,1, 0,2, 0,6 and 1,2 for trivial, small, moderate and large, respectively, *25-75%, possible; **75-95%, probable; ***95-99,5%, very probable.

With respect to CMJ, the mean pre-test jump height for CMJ was 39.58 cm and, similarly to SJ, there was a possibly decreased in jump height of 0.79 cm (-2.02%) than pre-test. Again, the residual muscle pain for the deep dry needling may prevent athletes to reach baseline values. After 48 hours, there was a likely trivial decreased improvement of 0.75 cm (+1.89%), followed by a possibly large rise in jump height of 3.54 cm (+8.94%) after 7 days from intervention.

With regards to graphical interpretation of meaningful differences in jump height as a consequence of the deep dry needling across the four stages, Figure 1 shows the vertical jump performances for SJ and CMJ. In the right axis, the three numbers denote the chances for the change to be a decrease/no change/increase and a qualitative probabilistic mechanistic inference about the true effect of the jump performance. The SWC, depicted in grey area in the plot, was set to 0.66 and 0.58 cm for SJ and CMJ, respectively, as 20% of between-sessions pooled SD.

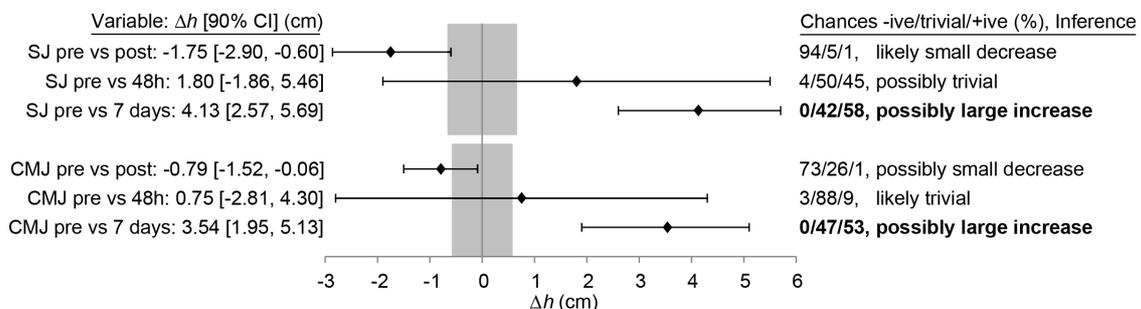


Figure 1: Interpretation by magnitude-based inferences of significant changes in SJ and CMJ jump height performances in elite beach volleyball players after dry needling intervention. The left axis shows the differences in jump height (95% confidence intervals) between pre-test and post-test, 48 h and 7 days. The right axis shows the percentage probability that the change is negative / no change / positive (jump height decrease / no change / increase) and the associated qualitative probabilistic mechanistic inference.

DISCUSSION

In this study, we quantified the acute and long-time effects of deep dry needling in latent Myofascial Trigger Points (MTrP) of vastus lateralis and medialis in jump performance of elite beach volleyball players. Although MTrP treatment is used to relieve pain and release trigger points in the muscle, that release can lead to improvements in muscle activity, resulting in a direct increase in jump height. The results demonstrated that such an intervention followed by 7 days allowed players to increase jump height with possibly large effect (3 times the smallest worthwhile change).

Beach volleyball is a sport characterized by intermittent short-period maximum efforts with fast and skilled executions on sand that are interspersed with frequent explosive vertical jumps (Oliveira et al. 2018). The combination of the above dynamic exercise and isometric contractions found in technical actions like spike, defense, setting or serve, may induce muscle fatigue and reduction of the maximum voluntary contraction force, thus causing MTrPs (Yu & Kim 2015). Particularly in beach volleyball, the existence of MTrPs can affect the

motor capacity of muscles and therefore the ability to jump. Thus, the elimination of latent MTrPs may effectively reduce accelerated muscle fatigue and prevent overload spreading within a muscle (Ge, Arendt-Nielsen, & Madeleine, 2012). The treatment of MTrPs with the deep dry needling has been extensively studied as pain relief, but the effect of such a technique on sports performance is still relatively unexplored (Devereux et al. 2018).

For interventions performed using dry needling, the pain reduction in the days after treatment was accompanied by adverse effects, such as soreness after needling, local hemorrhages, and syncopal responses (Kalichman & Vulfsons 2010). These adverse effects, together with the post-puncture pain, may explain the drop in jumping height of the athletes evaluated in the intervention. After 48 hours, SJ and CMJ jump height values approximately returned to pre-test, with minor trivial improvements. Other studies showed different degrees of jump increase after the intervention and after 48 hours. Geist et al. (2017) investigated the effectiveness of dry needling on hamstring flexibility and a series of jump tests as measures of functional performance, compared to blunt needles. They were unable to identify clinically significant improvements from the intervention. In another study on the treatment of pain in an athlete with more than 20 years of experience and diagnosed with tennis elbow, a single session with dry needling, reported an improvement 48 hours after treatment, being able to carry out a return to training with elastic bands without pain 7 days later (Shariat et al., 2018). Otherwise, Devereux et al. (2018) published a paper investigating the effect of dry needling on gastrocnemius, rectus femoris, combined muscles with controls on SJ jump performance at 5 incremental loads. They identified a significant increase in the gastrocnemius muscle group only immediately after the intervention and 48 hours later. Bandy et al. (2017) compared the effect of dry needling with the placebo group on the performance of the vertical jump applied to the gastrocnemius muscles, increasing the height of the vertical jump after the intervention. For the latter and in the sample of our study, the gradual improvement in hemodynamics may explain the improvement in response on days 1 to 3 after treatment (Jimbo, Atsuta, Kobayashi, & Matsuno, 2008).

Researchers have also demonstrated that pain begins to disappear after treatment, but it is necessary to wait a week for the muscle to fully recover its functionality (Lee, Chen, Lee, Lin, & Chan, 2008). This muscle function recovery after dry needling intervention to eliminate the MTrPs could explain the improvement in jump heights for SJ and CMJ. In addition to reduced pain inhibition of movement, the needle stretching of muscle fibers allows for a normal length resume (Osborne & Gatt, 2010).

Although these results suggest a direct improvement of jumping capacity, there are several factors that hinder the generalized use of this type of technique. The first factor is the low sample size of this study of elite players, which precluded the use of a placebo or control group. It would also be beneficial to complete a follow-up evaluation after seven days to address the effects of the intervention. Similarly, it would be necessary to evaluate the general and unwanted performance effects of continued use of this type of technique, especially the duration of pain after treatment and its effect on healthy athletes. In addition, it

is necessary to have specialized personnel to carry out the dry needling technique properly and safely. On the other hand, pain after the intervention can condition the training routine of athletes and even force them to interrupt their training. Also, invasive techniques are often rejected by athletes who prefer to receive other types of classical and painless treatments such as manual therapy. However, this treatment can provide possibilities in moderate use at specific times, so that athletes can be prepared and optimized for specific events, competitions, or specific matches. Therefore, its application in athletes can be considered for the improvement of muscular activity.

CONCLUSION

The treatment of latent MTrPs through deep dry needling in healthy beach volleyball athletes has shown acute and long-time effects on leg muscle response. Just after the intervention, jump height likely decreased due to the soreness in their muscles. This decrease in post-test performance discourages practitioners from using deep dry needling before competitions. When pain disappeared after 48 hours, jump performance rose to pre-test levels but the effect was trivial. However, in the tests performed after 7 days from intervention, there was a possibly large increase in jump performance with jump heights around 10% larger than pre-intervention. In conclusion, the treatment of latent MTrPs with deep dry needling has shown long-term positive effects on the musculature of the vast lateral and vast medial quadriceps, obtaining jump improvements in SJ and CMJ tests 7 days after treatment. In future studies, similar enhancements may be observed for other muscle groups in jumping performance.

REFERENCES

- Bandy, W. D., Nelson, R., & Beamer, L. (2017). Comparison of dry needling vs. sham on the performance of vertical jump. *International Journal of Sports Physical Therapy*, 12(5), 747–751. <https://doi.org/10.26603/ijsp20170747>
- Buchheit, M. (2016). The Numbers Will Love You Back in Return — I Promise. *International Journal of Sports Physiology and Performance*, (11), 551–554.
- Cross, K. M., & McMurray, M. (2017). Dry needling increases muscle thickness in a subject with persistent muscle dysfunction: A case report. *International Journal of Sports Physical Therapy*, 12(3), 468–475.
- Dembowski, S. C., Westrick, R. B., Zylstra, E., & Johnson, M. (2013). Treatment of hamstring strain in a collegiate pole-vaulter integrating dry needling with an eccentric training program: A resident's case report. *International Journal of Sports Physical Therapy*, 8(3), 328–339.
- Devereux, F., O'Rourke, B., Byrne, P. J., Byrne, D., & Kinsella, S. (2018). The effects of myofascial trigger point release on the power and force production in the lower limb kinetic chain. *Journal of Strength and Conditioning Research*, 33(9), 2453–2263. <https://doi.org/10.1519/JSC.0000000000002520>
- Ge, H. Y., Arendt-Nielsen, L., & Madeleine, P. (2012). Accelerated muscle fatigability of latent myofascial trigger points in humans. *Pain Medicine (United States)*, 13(7), 957–964. <https://doi.org/10.1111/j.1526-4637.2012.01416.x>
- Geist, K., Bradley, C., Hofman, A., Koester, R., Roche, F., Shields, A., ... Johanson, M. (2017). Clinical effects of dry needling among asymptomatic individuals with hamstring tightness: A randomized controlled trial. *Journal of Sport Rehabilitation*, 26(6), 507–517. <https://doi.org/10.1123/jsr.2016-0095>
- Hong, C.Z., & Simons, D. G. (1998). Pathophysiologic and electrophysiologic mechanisms of myofascial trigger points. *Archives of Physical Medicine and Rehabilitation*, 79(7), 863–872.
- Hopkins, W. G. (2007). A spreadsheet for deriving a confidence interval, mechanistic inference and clinical inference from a p value. *Sportscience*, 11, 16–20.
- Hopkins, William G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise*, 41(1), 3–12. <https://doi.org/10.1249/MSS.0b013e31818cb278>
- Hsieh, Y. L., Yang, C. C., Liu, S. Y., Chou, L. W., & Hong, C. Z. (2014). Remote dose-dependent effects of dry needling at distant myofascial trigger spots of rabbit skeletal muscles on reduction of substance P levels of proximal muscle and spinal cords. *BioMed Research International*, 2014. <https://doi.org/10.1155/2014/982121>
- Jimbo, S., Atsuta, Y., Kobayashi, T., & Matsuno, T. (2008). Effects of dry needling at tender points for neck pain (Japanese: Katakori): Near-infrared spectroscopy for monitoring muscular oxygenation of the trapezius. *Journal of Orthopaedic Science*, 13(2), 101–106. <https://doi.org/10.1007/s00776->

007-1209-z

- Jimenez-Olmedo, J. M., & Penichet-Tomas, A. (2017). Blocker's activity at men's european beach volleyball university championship: Actividad de los bloqueadores durante el Campeonato de Europa Universitario de vóley playa. *Retos. Nuevas Tendencias En Educacion Física, Deporte y Recreación*, 32, 252–255.
- Kalichman, L., & Vulfsons, S. (2010). Dry needling in the management of musculoskeletal pain. *The Journal of the American Board of Family Medicine*, 23(5), 640–646. <https://doi.org/10.3122/jabfm.2010.05.090296>
- Lee, S. H., Chen, C. C., Lee, C. S., Lin, T. C., & Chan, R. C. (2008). Effects of needle electrical intramuscular stimulation on shoulder and cervical myofascial pain syndrome and microcirculation. *Journal of the Chinese Medical Association*, 71(4), 200–206. [https://doi.org/10.1016/S1726-4901\(08\)70104-7](https://doi.org/10.1016/S1726-4901(08)70104-7)
- Liu, L., Huang, Q. M., Liu, Q. G., Thitham, N., Li, L. H., Ma, Y. T., & Zhao, J. M. (2018). Evidence for dry needling in the management of myofascial trigger points associated with low back pain: A systematic review and meta-analysis. *Archives of Physical Medicine and Rehabilitation*, 99(1), 144–152. <https://doi.org/10.1016/j.apmr.2017.06.008>
- Medeiros, A., Marcelino, R., Mesquita, I. M., & Palao, J. M. (2017). Performance differences between winning and losing under-19, under-21 and senior teams in men ' s beach volleyball. *International Journal of Performance Analysis in Sport*, 17(1–2), 1–13. <https://doi.org/10.1080/24748668.2017.1304029>
- Medeiros, A., Marcelino, R., Mesquita, I., & Palao, J. M. (2014). Physical and temporal characteristics of under 19, under 21 and senior male beach volleyball players. *Journal of Sports Science and Medicine*, 13(3), 658–665.
- Oliveira, W. K., Jesus, K. de., Andrade, A. D., Nakamura, F. Y., Assumpção, C. O., & Medeiros, A. I. (2018). Monitoring training load in beach volleyball players: a case study with an olympic team. *Motriz: Revista de Educação Física*, 24(1), 1–8. <https://doi.org/10.1590/s1980-6574201800010004>
- Osborne, N. J., & Gatt, I. T. (2010). Management of shoulder injuries using dry needling in elite volleyball players. *Acupuncture in Medicine : Journal of the British Medical Acupuncture Society*, 28(1), 42–45. <https://doi.org/10.1136/aim.2009.001560>
- Pueo, B., Lipinska, P., Jiménez-Olmedo, J. M., Zmijewski, P., & Hopkins, W. G. (2017). Accuracy of jump-mat systems for measuring jump height. *International Journal of Sports Physiology and Performance*, 12(7), 959–963. <https://doi.org/10.1123/ijsp.2016-0511>
- Rainey, C. E. (2013). The use of trigger point dry needling and intramuscular electrical stimulation for a subject with chronic low back pain: a case report. *International Journal of Sports Physical Therapy*, 8(2), 145–161.
- Sánchez-Sixto, A., Harrison, A. J., & Floría, P. (2019). Importance of countermovement depth in stretching and shortening cycle analysis. *Revista Internacional de Medicina y Ciencias de la Actividad Física y del Deporte*, 19(73), 33–44. <https://doi.org/10.15366/rimcafd2019.73.003>
- Shariat, A., Noormohammadpour, P., Memari, A. H., Ansari, N. N., Cleland, J. A., & Kordi, R. (2018). Acute effects of one session dry needling on a chronic golfer's elbow disability. *Journal of Exercise Rehabilitation*, 14(1),

- 138–142. <https://doi.org/10.12965/jer.1836008.004>
- Simons, D. G. (2004). Review of enigmatic MTrPs as a common cause of enigmatic musculoskeletal pain and dysfunction. *Journal of Electromyography and Kinesiology*, 14(1), 95–107. <https://doi.org/10.1016/j.jelekin.2003.09.018>
- Yu, S. H., & Kim, H. J. (2015). Electrophysiological characteristics according to activity level of myofascial trigger points. *Journal of Physical Therapy Science*, 27(9), 2841–2843. <https://doi.org/10.1589/jpts.27.2841>

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