Effect of Dry Needling on Thigh Muscle Strength and Hip Flexion in Elite Soccer Players

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[1]Department of Prevention and Sports Medicine, Technische Universität München, Munich, GERMANY; [2]Department of Sport Science and Kinesiology, University of Salzburg, AUSTRIA; [3]FC Ingolstadt Soccer GmbH, Ingolstadt, GERMANY; [4]Statistical Constultant, Puchheim, GERMANY; and [5]Department of Sport Medicine Humboldt University and Charité University School of Medicine, Berlin, GERMANY

ABSTRACT

HASER, C., T. STÖGGL, M. KRINER, J. MIKOLEIT, B. WOLFAHRT, J. SCHERR, M. HALLE, and F. PFAB. Effect of Dry Needling on Thigh Muscle Strength and Hip Flexion in Elite Soccer Players. *Med. Sci. Sports Exerc.*, Vol. 49, No. 2, pp. 378–383, 2017. **Purpose**: Increase in muscle force, endurance, and flexibility is desired in elite athletes to improve performance and to avoid injuries, but it is often hindered by the occurrence of myofascial trigger points. Dry needling (DN) has been shown effective in eliminating myofascial trigger points. **Methods**: This randomized controlled study in 30 elite youth soccer players of a professional soccer Bundesliga Club investigated the effects of four weekly sessions of DN plus water pressure massage on thigh muscle force and range of motion of hip flexion. A group receiving placebo laser plus water pressure massage and a group with no intervention served as controls. Data were collected at baseline (M1), treatment end (M2), and 4 wk follow-up (M3). Furthermore, a 5-month muscle injury follow-up was performed. **Results**: DN showed significant improvement of muscular endurance of knee extensors at M2 ($P = 0.039$) and M3 ($P = 0.008$) compared with M1 (M1:294.6 ± 15.4 N·m·s^{-1}, M2:311 ± 25 N·m·s^{-1}; M3:316.0 ± 28.6 N·m·s^{-1}) and knee flexors at M2 compared with M1 (M1:163.5 ± 10.9 N·m·s^{-1}, M2:188.5 ± 16.3 N·m·s^{-1}) as well as hip flexion (M1: 81.5° ± 3.3°, M2:89.8° ± 2.8°; M3:91.8° ± 3.8°). Compared with placebo (3.8° ± 3.8°) and control (1.4° ± 2.9°), DN (10.3° ± 3.5°) showed a significant ($P = 0.01$ and $P = 0.0002$) effect at M3 compared with M1 on hip flexion; compared with nontreatment control (−10 ± 11.9 N·m), DN (5.2 ± 10.2 N·m) also significantly ($P = 0.049$) improved maximum force of knee extensors at M3 compared with M1. During the rest of the season, muscle injuries were less frequent in the DN group compared with the control group. **Conclusion**: DN showed a significant effect on muscular endurance and hip flexion range of motion that persisted 4 wk posttreatment. Compared with placebo, it showed a significant effect on hip flexion that persisted 4 wk posttreatment, and compared with nonintervention control, it showed a significant effect on maximum force of knee extensors 4 wk posttreatment in elite soccer players. **Key Words:** DRY NEEDLING, MOBILITY, ENDURANCE, FORCE, ATHLETES, SOCCER, MUSCLE INJURIES

Muscular strains of the lower limb are among the most common injuries in sports and comprise approximately one third of all referrals to sports physicians (1,2,16). Hamstring injuries in particular are the most common type of muscular strain to affect the lower limb in the elite athlete (1,9). Muscle injuries are associated with sports that involve rapid acceleration or deceleration, jumping, cutting, pivoting, turning, or kicking and result in significant time off sport and often impaired performance on return to activity. In professional elite soccer teams, muscle injuries mainly affect the four big muscle groups in the lower limbs (92% of all muscle injuries) with hamstring muscles most often involved (8). Muscle injuries constitute almost one third of all time-loss injuries in men's professional soccer and result in a mean layoff period of 19 d and an injury rate of 1.0 per 1000 h played (7,8). In professional baseball, hamstring injuries comprise an injury rate of 0.7 per 1000 appearances; the mean time of return to play after a muscle injury is reported to be around 24 d (major leagues) and 27 d (minor leagues), with two thirds of the injuries resulting in more than 7 d of time loss (1). In professional sports, muscle injuries are therefore a substantial problem for players and their clubs (8).

Reported risk factors for muscle injuries include tightness of muscles, previous muscle injury, age, ethnicity, strength imbalances, reduced flexibility, fatigue, previous osteitis pubis, or knee injury as well as higher BMI (17,18,28). In professional soccer players, muscle injuries seem to be associated with high match load (2). Furthermore, intrinsic factors associated with increased muscle injury rates in professional soccer are previous injury, older age, and kicking leg (9).

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Some of these risk factors—tightness of muscles and reduced flexibility and strength—have been associated with myofascial trigger points (TrP). TrP are hyperirritable points located within a taut band of skeletal muscle or fascia. They typically cause referred pain, local tenderness, and autonomic changes when compressed (3,25). Risk factors for TrP development are muscle overuse or direct trauma to the muscle. Muscle overload is hypothesized to be the result of sustained or repetitive low-level muscle contractions, eccentric muscle contractions, and maximal or submaximal concentric muscle contractions (3).

One method for the treatment of myofascial TrP is the technique of dry needling (DN) (29). In this technique, a sterile thin acupuncture needle is inserted into a TrP eliciting a twitch response (fast muscle contraction) leading to a change in the milieu of local inflammatory parameters (29). Randomized controlled clinical trials point toward effects of DN in treatment of ankle instability (21), mechanical neck pain (13,15,19), poststroke spasticity (22), plantar heel pain (5), fibromyalgia (4), and myofascial pain syndrome (6,26). As the treatment of DN often results in short-term soreness and increased sensitivity of the treated area, it is often accompanied by spray and stretch treatment or massage therapies such as water pressure massage (14). Although scientific evidence points toward specific clinical effects of DN on muscle function and associated pain syndromes, so far no study has been conducted evaluating muscle performance and flexibility.

This study aimed at investigating the effects of DN in combination with water pressure massage on thigh muscle strength and hip flexion range of motion in elite youth soccer players of a professional soccer Bundesliga Club in Germany. A group receiving placebo laser in combination with water pressure massage and a group receiving no intervention served as controls.

METHODS

Study Design

This is a randomized, prospective, three-arm, blinded controlled study of 30 soccer players. The included players were position and team matched (e.g., three goalkeepers of one team randomized into three groups, three strikers of each team, etc.). The study was conducted according to the guidelines of Helsinki and approved by the local ethics committee of the Technische Universität Munich, Germany.

DN with water pressure massage was compared with placebo laser (inactive laser device) with water pressure massage (PL) each once per week for 4 wk and a control group (CO) with no intervention. Collection of data occurred at baseline before treatment (M1), at end of treatment (M2 = 4 wk post-M1), and after 4 wk follow-up (M3) (Fig. 1). Participants as well as therapist were blinded regarding the laser-controlled treatment; the examiner taking care of the measurement of outcome parameters was blinded.

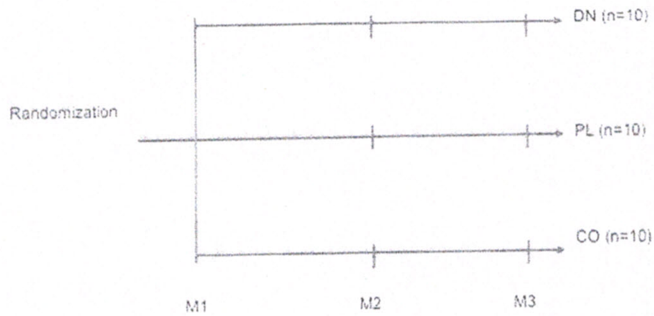

FIGURE 1—Study design. Measurement 1 (M1): before treatment (baseline); measurement 2 (M2): end of treatment = 4 wk post-M1; measurement 3 (M3): 8 wk post-M1. Treatments: DN with water pressure massage (DN) and placebo laser with water pressure massage (PL) each once per week for 4 wk; the control group (CO) received no intervention.

Subjects

Thirty healthy semiprofessional soccer players of the U19 (age, 18 or 19 yr) and U23 (age, 18–23 yr) soccer teams of a professional German Bundesliga soccer club with a mean age of 18.4 yr were included (see Table, Supplemental Digital Content 1, Demographic data [age, leg dominance, and playing position, http://links.lww.com/MSS/A765] given as mean and confidence interval). One player who had been randomized to the control group signed with another team during the study and therefore had to be excluded. Informed written consent was obtained by all athletes as well as the soccer club, and all players had passed a thorough medical check before the study at the department of sports medicine of the Technische Universität Munich, Germany. The subjects were informed to enroll in a study comparing two different therapies for the treatment of muscular TrP: DN and laser.

Exclusion criteria were current injuries, needle phobia, or blood coagulation disorders.

Training

Training took place five times a week each week of the study period, with no extra or individual training allowed during the study period. The amount, quality, and quantity of training and exercises were kept equal for all players by the coaches during the study period.

Interventions

Treatments took place once a week for a period of 4 wk. No other interventions, treatments, or medication other than the study treatments were allowed. In case of a necessary extra treatment, the patient had to be excluded from the study.

DN and Water Pressure Massage Group

The DN consisted of acupuncture needles inserted into TrP of the front and back of the athlete's thighs that were detected on soft palpation. When the needle elicited a local twitch response (involuntary spinal cord reflex in which the muscle fibers in the taut band of a muscle contract), it was immediately removed and a new needle inserted at a different TrP. This procedure was repeated for a period of 20 min in each athletes' treatment and conducted by the same therapist each session. DN was performed by a physician (FP) who specialized and was certified in sports medicine as well as acupuncture and has more than 15 yr of experience with this method in sports medicine. FP was supported by a certified sports physiotherapist/naturopath who had been trained in DN. Both therapists interchanged study participants during treatment; there was no "treatment ownership" of certain subjects. DN was followed by a 10-min water pressure massage of the thighs, which was conducted by a blinded physiotherapist each session.

Placebo Laser and Water Pressure Massage

The placebo laser treatment consisted of a treatment of 20 min of TrP of the thighs that were detected on soft palpation with an inactive laser (LASER Handy CW 100, Seirin) that emitted an infrared light. Both therapists as well as athletes believed the laser to be fully working; both were blinded until the end of the last measurement. The placebo laser treatment was followed by a 10-min water pressure massage of the thighs, which was conducted by the same blinded physiotherapist as in the DN group each session.

Outcome Parameters

Data collection occurred at baseline (M1), "posttherapy" (4 wk after baseline) (M2), and "follow-up" (12 wk after baseline) by the same blinded observer (M3) (Fig. 1).

Maximum muscular strength of knee extension as well as knee flexion. Isometric measurements with rotation velocity of $60°\cdot s^{-1}$ of both sides—each side tested separately by Cybex Norm TM Testing and Rehabilitation System. Knee extensors were measured at 60° knee flexion; knee flexors at 30° flexion. Outcome parameter was the mean value of the two maximum values (of two measurements on each side), calculated for knee extensors as well as knee flexors.

Muscular endurance knee extension and knee flexion. Isokinetic measurements had a rotation velocity of $180°\cdot s^{-1}$ on both sides—each side tested separately by Cybex Norm TM Testing and Rehabilitation System (movement velocity 70% of maximum isometric performance) (20). Knee motion was set between 90° and 180° knee flexion. Subjects had to extend and flex 25 times with maximum performance. Outcome parameter was mean performance ($N\cdot m\cdot s^{-1}$) during these 25 knee flexions and extensions.

Range of motion of hip flexion. Hip flexion range of motion was measured by Straight Leg Raise Test with a plurimeter (Baseline, Bubble Inclinometer). Subjects lay on their back with core and hip in neutral position. The blinded examiner moved the subject's leg into a vertical position with one hand placed on the ventral knee joint preventing knee flexion, the other placed at the Achilles tendon pushing the leg upward until further movement was not possible or lower spine movement occurred. This end position was measured by plurimeter.

Statistics

Statistical analyses were performed using R 3.1.0 (R Core Team (2014). R: A language and environment for statistical computing; R Foundation for Statistical Computing, Vienna, Austria, http://www.R-project.org/). Demographic data and the outcome parameters are presented as mean ± SD per treatment group and time point of measurement, respectively. For graphical illustration, box plots were drawn. The measured covariates were tested on normality using the Shapiro–Wilk test in every group and at every time point. The covariate means of the different time points per treatment group were compared using repeated-measures ANOVA. In case of significance, *post hoc* analyses were conducted using Student's *t*-test for paired samples. The comparison between the three treatment groups concerning the changes in the outcome variables over time (differences M2–M1 and M3–M1, respectively) was conducted using one-way ANOVA for independent samples. In case of significance, *post hoc* analyses were conducted using Student's *t*-test for independent samples. Results are presented in form of the *F* value of the test statistic and the *P* value. Level of significance was set at $\alpha < 0.05$.

TABLE 1. Maximum force and endurance of knee flexors and extensors as well as degrees of hip flexion given as mean and confidence intervals at baseline (M1), posttreatment (M2), and 2-month follow-up (M3) in control, placebo laser, and DN groups.

			Baseline (M1)	Posttherapy (M2)	2-Month Follow-up (M3)	P (ANOVA)
Knee extension	Max force (N·m)	Control	216.8 ± 12.8	210.9 ± 14.1	203.2 ± 13.9	0.1278
		Placebo laser	211.2 ± 14.0	211.8 ± 15.5	208.2 ± 16.4	0.7079
		DN	230.7 ± 12.6	226.5 ± 15.3	235.9 ± 19.6	0.1659
	Endurance (N·m·s^{-1})	Control	263.8 ± 17.7	284.7 ± 17.0	273.3 ± 15.6	0.1769
		Placebo laser	259.9 ± 18.6	277.3 ± 22.1	271.2 ± 22.8	0.1204
		DN	294.6 ± 15.4	311.0 ± 25.4*	316.0 ± 28.6**	0.0259
Knee flexion	Max force (N·m)	Control	124.5 ± 7.9	134.6 ± 9.8	133.2 ± 10.4	0.0591
		Placebo laser	123.9 ± 6.4	130.1 ± 8.7	127.6 ± 9.9	0.097
		DN	136.0 ± 11.7	142.7 ± 11.5	148.4 ± 14.8	0.0694
	Endurance (N·m·s^{-1})	Control	165.9 ± 12.3	180.2 ± 16.1	180.9 ± 17.8	0.1114
		Placebo laser	162.2 ± 13.5	166.8 ± 13.7	172.5 ± 17.0	0.3276
		DN	163.5 ± 10.9	188.5 ± 16.3**	180.2 ± 18.0	0.0007
Hip flexion (°)		Control	83.0 ± 3.2	83.3 ± 4.3	84.4 ± 2.2	0.2698
		Placebo laser	79.8 ± 5.7	83.8 ± 4.3*	83.5 ± 4.4*	0.0159
		DN	81.5 ± 3.3	89.8 ± 2.8**	91.8 ± 3.8**	<0.0001

The last column (*P* ANOVA) shows the *P* values for ANOVA three-group comparison. Stars mark significant intergroup differences to baseline in *post hoc* tests in case of significant three-group comparison differences (*$P < 0.05$; **$P < 0.01$).

RESULTS

One player in the control group dropped out of the study after the second measurement (M2) because he transferred to a different team. All other athletes completed the study.

Treatment Effect

Comparisons within groups. The Shapiro–Wilk test revealed no deviation from the normal distribution for the covariates; thus, repeated-measures ANOVA could be used for comparison of the different time points within the three treatment groups (Table 1). The DN group showed a significantly higher endurance of knee extension at M2 (311 ± 25.4 N·m, $P = 0.039$) and M3 (316.0 ± 28.6 N·m, $P = 0.008$) compared with M1 (294.6 ± 15.4 N·m), whereas the placebo laser group showed a slight but not significant improvement at M2 (277.3 ± 22.1 N·m, $P = 215$) and M3 (271.2 ± 22.8 N·m, $P = 0.428$) compared with M1 (259.9 ± 18.6 N·m).

The DN group also showed a significantly ($P = 0.0001$) higher endurance of knee flexion at M2 (188.5 ± 16.3 N·m·s^{-1}) compared with M1 (163.5 ± 10.9 N·m·s^{-1}), whereas the placebo laser group showed little improvement ($P = 0.622$) at M2 (166.8 ± 13.7 N·m·s^{-1}) compared with M1 (162.2 ± 13.5 N·m·s^{-1}).

Regarding the range of motion of hip flexion, DN showed a significantly higher range of motion at M2 (89.8° ± 2.8°, $P < 0.0001$) and M3 (91.8° ± 3.8°, $P < 0.0001$) compared with M1 (81.5° ± 3.3°); placebo laser also showed a significantly higher range of motion at M2 (83.8° ± 4.3°, $P = 0.0166$) and M3 (83.5° ± 4.4°, $P = 0.0478$) compared with M1 (79.8° ± 5.7°).

The control group with no intervention showed no significant improvements in any within-group comparison.

Group comparisons. Table 2 presents the results of the differences between treatment end and baseline (M2-M1) between the groups. Only the range of hip flexion motion showed a significant difference between groups ($P = 0.0003$). *Post hoc* tests revealed a significant difference between the DN group (8.3° ± 3.2°) and the control group (0.3° ± 2.6°) ($P = 0.0002$).

Table 2 also presents the results of this analysis comparing the differences between follow-up and baseline (M3–M1). The maximum strength of knee extensors ($P = 0.035$) (Fig. 2) as well as the range of hip flexion motion ($P = 0.0003$) (Fig. 3) showed a significant difference between groups. Regarding the range of hip flexion motion, *post hoc* tests revealed a significant difference between the DN group (10.3° ± 3.5°) and the control group (1.4° ± 2.9°) ($P = 0.0002$) as well as between the DN and the placebo laser groups (3.8° ± 3.8°) ($P = 0.01$). *Post hoc* tests also revealed a significant difference between the DN group (5.2 ± 10.2 N·m) and the control group (−10 ± 11.9 N·m) regarding the maximum strength of knee extensors ($P = 0.049$).

TABLE 2. Results of one-way ANOVA comparing the differences to baseline of posttherapy (M2–M1) and 2-month follow-up (M3–M1) between all groups (changes in outcome parameters).

	F	P
Variable (M2–M1)		
Change in maximum force knee flexors	0.681	0.413
Change in muscular endurance knee flexors	0.942	0.336
Change in maximum force knee extensors	0.098	0.755
Change in muscular endurance knee extensors	0.017	0.896
Change in hip flexion range of motion	15.250	0.0003
Variable (M3–M1)		
Change in maximum force knee flexors	0.302	0.585
Change in muscular endurance knee flexors	0.004	0.95
Change in maximum force knee extensors	4.663	0.0351
Change in muscular endurance knee extensors	1.474	0.23
Change in hip flexion range of motion	14.81	0.0003

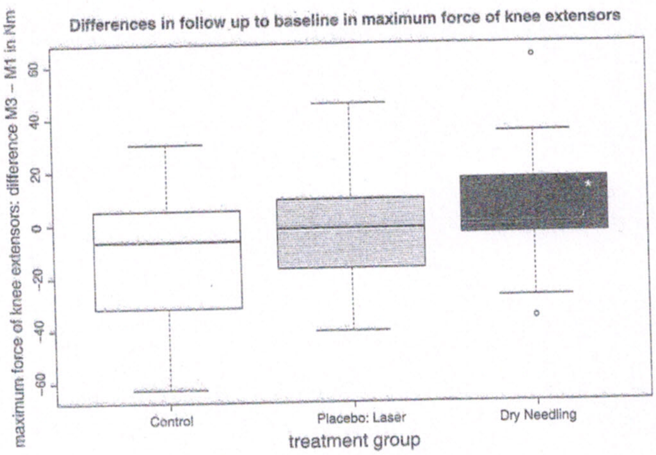

FIGURE 2—Differences in follow-up to baseline in maximum force of knee extensors. *Significant difference ($P < 0.05$) between the DN group and the placebo laser group ($P = 0.049$).

Subsequent injuries and resulting recovery time until return to play during the ongoing soccer season (5-month follow-up). One player who had received DN and under water pressure massage therapy had a minor strain resulting in a time off team training of 6 d (Table 3). Four players who had received placebo laser and under water pressure massage therapy had subsequent injuries (three minor strains and one muscle fiber tear). Total time off team training in this group was 37 d (6, 5, 4, and 22 d). Three players of the control group with no intervention had subsequent injuries (one minor strain, one muscle fiber tear, and one muscle bundle tear). The control group had a total time off team training of 58 d. Comparing the number of injuries between groups, chi-square analysis showed no significant difference ($P = 0.30$) between groups.

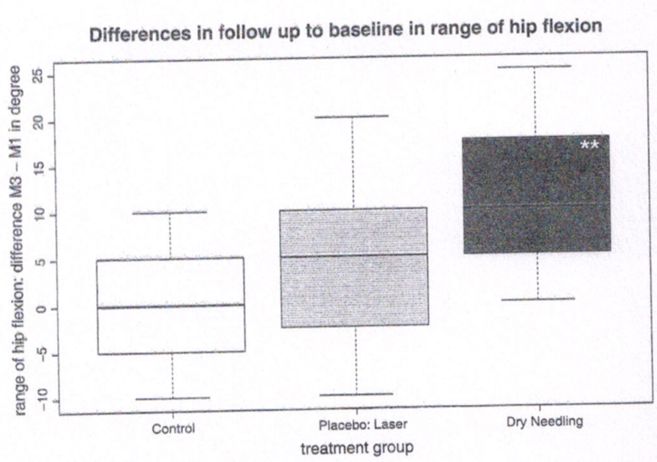

FIGURE 3—Differences in follow-up to baseline in the range of motion of hip flexion. **Significant difference between the DN group and the placebo laser group ($P = 0.01$) and no intervention control ($P = 0.0002$).

TABLE 3. Muscular injuries and resulting recovery time until return to play during the ongoing soccer season (5-month follow-up).

	DN	Placebo Laser	Control
Type of injury	1: strain	1–3: strains; 4: muscle fiber tear	1: strain; 2–3: muscle fiber tear
Localization	1: left biceps femoris	1 and 3: left calf; 2: left adductor; 3: right biceps femoris	1: right adductor; 2: right semimembranosus; 3: right biceps femoris
Time until return to training	1: 6 d	1: 6 d; 2: 5 d; 3: 4 d; 4: 22 d	1: 4 d; 2: 18 d; 3: 36 d

Blinding

At the end of the study when questioned, all athletes in the placebo laser group believed to have received an actual laser treatment. The person conducting the therapy believed to have used an active laser device.

DISCUSSION

DN showed significant improvements of muscular endurance of knee extensors and hip flexion that persisted 4 wk posttreatment as well as a short-term improvement of muscular endurance of knee flexors in the intragroup analysis. Compared with placebo, DN showed a significant effect on hip flexion that persisted 4 wk posttreatment. Compared with a nontreatment control, DN also significantly improved maximum force of knee extensors also 4 wk posttreatment. Compared with a nontreatment control, placebo laser combined with water pressure massage resulted in a small but statistically significant improvement of hip flexion range of motion at treatment end and 4 wk posttreatment.

Compared with both control groups, DN did not result in a significant amount of less muscle-injured players with a reduced time off training.

This is the first study investigating the effect of DN on muscular range of motion and lower extremity muscle strength. It is also the first study to investigate an acupuncture technique in elite soccer players. DN has not been investigated scientifically until recently. Within the last year, evidence toward a clinical effect of DN in diseases associated with muscle tension is growing. Mejuto-Vazquez et al. (15), Pecos-Martin et al. (19), and Llamas-Ramos et al. (13) recently reported a specific effect of DN on neck pain and cervical range of motion in chronic pain patients. Further randomized controlled trials point to the specific effects of DN in the treatment of myofascial pain syndrome (6,26), poststroke spasticity (22), fibromyalgia (4), ankle instability (21), and plantar heel pain (5).

Liu et al. (12) systematically reviewed the effect of DN for TrP associated with neck and shoulder pain, showing a specific and significant short- and medium-term effect. Current studies also suggest that DN may be helpful in reducing pain in the upper quarter and craniofacial region (11) and plantar heel region (5).

Shah et al. (23,24) found higher concentrations of substance P (SP), calcitonin gene–related peptide, bradykinin, 5-hydroxytryptamine/serotonin, norepinephrine, tumor necrosis factor α, and interleukin 1β in myofascial TrP. After DN, SP and calcitonin gene–related peptide concentrations significantly dropped corresponding with less clinical tenderness and pain of TrP. Besides the mechanical tissue stimulus with a change in the milieu of local inflammatory parameters (29), remote reduction of inflammatory neuromediators such as SP may also be responsible for the effect of DN (10).

The small but significant improvement in the range of motion of hip flexion in the placebo laser and water pressure massage group points toward an effect of water pressure massage on muscular flexibility; further studies need to explore this effect. Scientific data on the effect of water pressure massage or hydrotherapy are so far very limited. Tomasik (27) described a significantly more rapid decrease in plasma lactic acid after exercise in subjects treated with hydrotherapy compared with controls with no intervention.

Limitations of this study are the relatively small number of included athletes (because of the size of a soccer team) as well as the difficulty of blinding of DN, which is felt as a twitching often painful stimulus as mentioned previously.

High-quality published studies in elite soccer players are still rare. Possible reasons may include challenges in designing a well-controlled study in a professional sports team with its limited amount of athletes, often individualized treatment and training protocols, and difficulty blinding athletes, therapists, trainers, and managers. Another reason may be that in professional sports, data are often not published, as its main purpose is for further improvement of the own teams' performance.

In conclusion, DN showed a significant effect on hip flexion range of motion that persisted 4 wk posttreatment compared with a placebo and on maximum force of knee extensors 4 wk post treatment compared with a nontreatment control in elite soccer players. Further studies need to verify the clinical effects, explore potential mechanisms, and explore a potential injury-preventing effect.

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