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ORIGINAL

COMPARISON OF A PROPRIOCEPTIVE TRAINING PROGRAM ON STABLE BASE AND UNSTABLE BASE

COMPARACIÓN DE UN ENTRENAMIENTO PROPIOCEPTIVO SOBRE BASE ESTABLE Y BASE INESTABLE

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ABSTRACT

The aim is to compare two proprioceptive training programs on a stable (G1) and an unstable (G2) base in terms of balance and stability. During a 5 week period, 18 professional football players underwent a proprioceptive training program, 9 in G1 and the other 9 in G2. The Standard Excursion Balance Test was applied before and after the intervention program. Significant intragroup differences were found in the variables LEFT FRONT, ANTEROLATERAL LEFT (ANTLAT.LEFT), BACK RIGHT and ANTEROMEDIAL RIGHT (ANTMED.RIGHT) (p<0,005) for the G1, and FRONT RIGHT, FRONT LEFT, POSTMED.RIGHT, POSTMED.LEFT and MED.RIGHT (p <0,005) for G2. We conclude that there are no significant differences between the unstable base training and training stable base regarding improvement in balance and stability.

KEY WORDS: Balance, Exercise, Injury Prevention, Proprioception.

RESUMEN

El objetivo de este estudio fue comparar dos programas de entrenamiento propioceptivo sobre base estable (G1) y base inestable (G2). Durante 5 semanas, 18 jugadores de fútbol profesional se sometieron a un programa de entrenamiento propioceptivo, 9 formaron el G1 y 9 G2. Se aplicó el Standard Excursion Balance Test (Test de Estrella) antes y después de la intervención. Los resultados intragrupo mostraron diferencias significativas en las variables ANT.IZDO; ANTLAT.IZDO; POST.D y ANTMED.D ($p<0{,}005$) para el G1 y ANT.D; ANT.IZDO; POSTMED.D; POSTMED.IZDO Y MED.D ($p<0{,}005$) para el G2. No se hallaron evidencias significativas entre el entrenamiento en base estable y base inestable para la mejora del equilibrio y la estabilidad.

PALABRAS CLAVE: Equilibrio, Ejercicio, Prevención de lesiones, Propiocepción.

INTRODUCTION

The boom in sports activity in contemporary societies, inadequate exercise programs and design, the requirements of such protocols and the increasing number of participants and competitions, among other factors, have led to a marked increase in the prevalence and incidence of disorders that affect the health and quality of life of individuals and, specifically, the locomotor system (Campos Izquierdo & Lalín Novoa, 2012).

Epidemiological studies have shown that injuries in sports or recreational fields have been considered one of the major health problems in developed countries (Belechri, Petridou, Kedikoglou, & Trichopoulos, 2001). Within the field of sport, football has a high level of global participation with over 200 million enthusiasts worldwide (Junge & Dvorak, 2004).

Lower limbs are more likely to be injured compared to upper limbs, quantified as 67.7% vs. 13.4%, respectively (Longo, Loppini, Cavagnino, Maffulli, & Denaro, 2012). On the other hand, it has been reported than in soccer 77% of the injuries occurred were lower extremity, compared to 33% produced in the upper limbs (Morgan & Oberlander, 2001). The most common acute injuries are muscle strains and ruptures, bruises and sprains (Arnason et al., 2004), and the vast majority of injuries are associated with the dominant side of the body (52.3%) as opposed to the non-dominant (38.7%) (Hawkins & Fuller, 1999).

The ankle is one of the most commonly injured joints among those doing sport. Furthermore, lateral external ligament ankle sprain (ELL) is one of the most common musculoskeletal injuries in athletes (Garrick, 1977; Hawkins & Fuller, 1999). These injuries can lead to a significant time away from sporting activity, disability, and high costs to the public health system (McGuine, Greene, Best, & Leverson, 2000). Usually, about 85% of ankle sprains are caused by a forced inversion and plantar flexion. Many studies have proved that sports where there are constant changes of pace and direction, such as football, have high percentages of this type of injury (Garrick, 1977; McGuine et al., 2000).

The knee is the joint that suffers more injuries in the competitive phase of the season. Some studies report figures of 30% incidence, compared to other studies that show an incidence of between 14% to 32% (Engebretsen, Myklebust, Holme, Engebretsen, & Bahr, 2010). Knee injuries account for 15% to 21% of all injuries in professional football players. In addition, 75 % refer to those suffered in Internal Lateral Ligament (Arnason et al., 2004; Hawkins & Fuller, 1999; Woods, Hawkins, Hulse, & Hodson, 2002). Lesions in the Anterior Cruciate Ligament (ACL) only represent 5% of injuries suffered by high level athletes (Giza & Micheli, 2005).

Proprioception is considered a source of sensory information that provides our bodies with information to intervene in neuromuscular control. The main receptors of the information described in the literature, refer to a “Ruffini Corpuscle”, “Pacini Corpuscle” and the neuromuscular fuses and tendon organs of the Golgi (Lephart, Pincivero, & Rozzi, 1998). The proprioceptive system, via the efferent reflex response to a previous afferent signal, allows a dynamic joint stability which is adequate to maintain balance (Mandelbaum et al., 2005). Proprioception is a key element in the training programs for the prevention of knee and ankle injuries (Hübscher et al., 2010; Lauersen, Bertelsen, & Andersen, 2013). A proper neuromuscular feedback provides an important component for stabilization and maintenance of joint stability (Lephart et al., 1998).

There is an important body of scientific evidence that justifies proprioceptive work in order to improve stability in ankle and knee joints. A pioneering study was conducted by Tropp and Askling (1988), who stated that in professional players, after six weeks of proprioceptive training on a Freeman dish (unstable), stability at monopodal level in the lower body limbs, had been improved. Along these lines, many authors state that proprioceptive training should be based on protocols where the use of unstable dishes be stressed. Other authors, however, determine that the best method for attaining better results is to combine stable and unstable planes (Eils & Rosenbaum, 2001; Paterno, Myer, Ford, & Hewett, 2004). The effects of proprioceptive programs were measured in different ways: through the activation time of the musculature of the limb to be evaluated (Eils & Rosenbaum, 2001), position of the center of mass (Bernier & Perrin, 1998; Tropp & Askling, 1988), or through the angulation of the relevant limb (Brooks, Potter, & Rainey, 1981). It is important to be able to establish the differences between the two types of training protocols and find which one is more useful in the sporting activity in order to prevent injuries.

The purpose of this study was to analyse the effect of a program of proprioceptive exercise training on knee and ankle stability, and to compare the effectiveness of proprioceptive training on stable base versus unstable base for improving knee and ankle stability.

METHODS

20 soccer players took part in the study. The players belong to the first team of a Spanish professional club (2nd Division). Inclusion criteria were: being a first team player; not having suffered any injury that had prevented the player from working in the group for 2 or more sessions, in the two weeks prior to the study; and having a medical evaluation at the start of the pre-season. Exclusion criteria were: having suffered an injury that had separated the player from the working group for 2 or more sessions, in the two weeks prior to the study; missing 2 or more training sessions during the intervention program; performing proprioceptive exercises outside of this training program; and suffering some kind of chronic joint injury.

The sample was divided into two groups at random. A group of 9 players formed Experimental Group 1 (G1) (25.89±3.85 aged; 1.78±0.053 m; 73.84±6.26 Kg.), which followed the stable base protocol. Experimental Group 2, (G2) (23.33±3 aged; 1.80±0.05 m; 74.87±6.11 Kg.) was also made up of 9 players, and followed the protocol on an unstable base. The study was conducted within the training dynamics of a professional football team as a routine preventive measure incorporated into their training sessions.

The *Star Excursion Balance Test* (SEBT) was used to estimate the stability of the lower body. This method is valid, reliable, economical and easily applicable to measuring stability in lower limbs (Plisky, Rauh, Kaminski, & Underwood, 2006). This test has been validated for estimating levels of stability in the joints of the lower body with a correlation of 0.67–0.87 (Kinzey & Armstrong, 1998). This was performed three times and an average of 3 repetitions was used as a final measure. The following repetitions were discarded: support foot moved to achieve more distance, support foot lifted while measuring, foot not remaining away from the foot mark reached, and, finally, lost balance (Plisky et al., 2006). In order to start the test, the limb to be evaluated was placed in the centre of the figure (Figure 1). The contralateral was mobilized previously to continue in the medial direction, trying to reach maximum distance in each direction. When testing in the lateral and posterolateral direction, the leg in motion has to pass behind the supporting leg (Chaiwanichsiri, Lorprayoon, & Noomanoch, 2005; Gribble & Hertel, 2003; Olmsted, Carciat, Hertel, & Shultz, 2002; Plisky et al., 2006). Also, before the start of the test, each subject had to perform 6 repetitions with each leg in every direction to be measured in order to become familiar with the test. After these repetitions on trial, there were stretches of the quadriceps muscles, hamstrings and triceps surae for 5 minutes.

Applying SEBT allowed us to estimate the following variables before and after training: Right Front (RIGHT FRONT); Left Front (LEFT FRONT); Anterolateral Right (ANTLAT.RIGHT); Anterolateral Left (ANTLAT.LEFT); Lateral Right (LAT.RIGHT); Lateral Left (LAT.LEFT); Posterolateral Right (POSTLAT.RIGHT); Posterolateral Left (POSTLAT.LEFT); Posterior Right (POST.RIGHT); Posterior Left (POST.LEFT); Posteromedial Right (POSTMED.RIGHT); Posteromedial Left (POSTMED.LEFT); Medial Right (MED.RIGHT); Medial Left (MED.LEFT); Anteromedial Right (ANTMED.RIGHT); Anteromedial Left (ANTMED.LEFT).

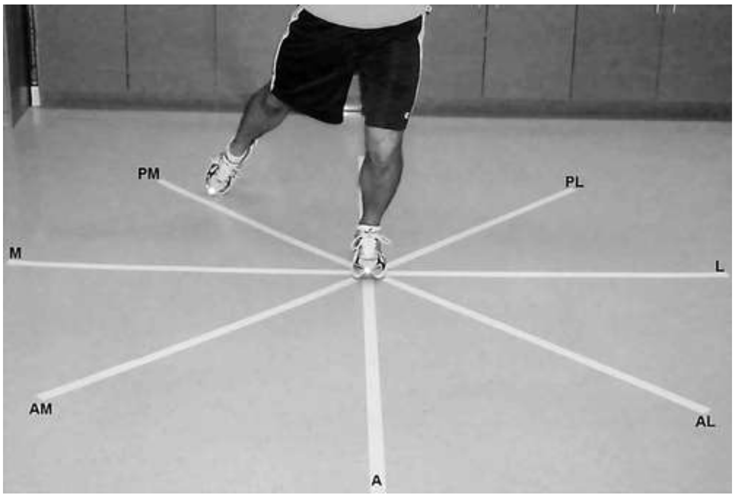

Figure 1. Star Excursion Balance Test

The pre-test and post-test were conducted in both groups before training so that the load did not affect the results. During the intervention phase identical training protocols were applied to both groups, changing only the support base, stable base for G1 and unstable for G2 (Table 1). The protocol was structured in 5 phases of one week each. The training frequency was 5 days/week in the first 4 phases and 3 days/week in the last phase (McGuine & Keene, 2006). The exercises developed in each of the phases were adapted to football, and were executed using a 4-station circuit. The working time was 30" each leg with leg changes after a 30" rest. The G2 circuit was performed on 4 unstable elements: soft mat, Freeman Dish, Fit-sit Platform and Dyn-air. Two training programs were taken as independent variables of the study (one of them to be developed on a stable base and the other on the unstable base), the dependent variables were the values attained when applying the S*tar Excursion Balance Test* (SEBT). All subjects had been previously informed about the purpose of the study and the type of tests to which they would be subjected, and signed informed consent forms before participating in the study according to the Declaration of Helsinki.

Table 1. Proprioceptive training protocol performed in the study

Phase	Sessions/ week	Eyes	Exercises
1	5	Open	1. Monopodal 2. Monopodal with free leg swing 3. Monopodal con squat at 30-45º in knee 4. Monopodal dynamic with load, shock…
2	5	Closed	1. Monopodal 2. Monopodal con with free leg swing 3. Monopodal con squat at 30-45º in knee 4. Monopodal dynamic with load, shock …
3	5	Open	1. Monopodal pass ball to hand 2. Monopodal with free leg swing pass ball to hand 3. Monopodal with squat at 30-45º in knee pass ball to hand 4. Monopodal dynamic with load, shock and pass ball to hand
4	5	Open	1. Monopodal pass ball to head 2. Monopodal with free leg swing pass ball to head 3. Monopodal with squad at 30-45º in knee pass ball to head 4. Monopodal dynamic with load, shock and pass ball to head
5	3	Open	1. Monopodal with pass ball to foot 2. Monopodal with free leg swing pass ball to head to foot 3. Monopodal with squat 30-45º in knee with pass ball to foot 4. Monopodal dynamic with load, shock and pass ball to foot

SPSS-18® program was used for the statistical analysis. We performed Shapiro-Wilk test to know if the variables were consistent with a normal distribution. Levenne test was conducted to determine the homoscedasticity. To contrast the hypothesis intragroups, normally distributed data were analyzed with Student-t test ($p < 0.05$). No normally distributed data were analyzed using Wilcoxon test ($p<0.05$). For intergroup comparison, we performed an analysis of covariance (ANCOVA), using pretest data as covariable ($p<0.05$). Assessment of the effect-size was included. The criteria applied to establish the magnitude of the change were: small (d=.20), medium (d=.50), and large (d=.80) (Cohen, 1988).

RESULTS

Below, the intragroup results are shown before and after the training period on a stable (Table 2) and an unstable base (Table 3). Significant statistical changes were observed in the variables: LEFT FRONT, ANTLAT.LEFT, RIGHT BACK and ANTMED.RIGHT, in G1. In G2, statistically significant differences were found in the variables: ANT.RIGHT, ANT.LEFT, POSTMED.RIGHT, POSTMED.LEFT and MED.RIGHT.

Table 2. Comparison of means pre-test and post-test in SEBT§ score on Stable Base Group (G1)

Variables	Pre-test (mean ± SD)	Post-test (mean ± SD)	p value	Effect Size Value	Effect Size Difference
FRONT RIGHT	0.89 ± 0.06	0.90 ± 0.05	.330	0.70	Moderate
FRONT LEFT	0.86 ± 0.06	0.89 ± 0.06	.000*	0.55	Moderate
ANTLAT.RIGHT	0.85 ± 0.11	0.85 ± 0.09	.633	0.11	Small
ANTLAT.LEFT	0.83 ± 0.08	0.86 ± 0.09	.004*	0.52	Moderate
LAT.RIGHT	0.84 ± 0.10	0.86 ± 0.10	.012*	0.19	Small
LAT.LEFT	0.82 ± 0.12	0.84 ± 0.11	.081	0.27	Small
POSTLAT.RIGHT	0.95 ± 0.05	0.96 ± 0.05	.097	0.52	Moderate
POSTLAT.LEFT	0.95 ± 0.07	0.96 ± 0.07	.160	0.19	Small
BACK.RIGHT	1.02 ± 0.05	1.04 ± 0.04	.002*	0.50	Moderate
BACK.LEFT	1.02 ± 0.05	1.04 ± 0.05	.062	0.50	Moderate
POSTMED.RIGHT	0.97 ± 0.08	0.98 ± 0.07	.051	0.63	Moderate
POSTMED.LEFT	0.98 ± 0.07	0.98 ± 0.07	.455	0.28	Small
MED.RIGHT	0.82 ± 0.13	0.83 ± 0.14	.221	0.76	Moderate
MED.LEFT	0.84 ± 0.15	0.85 ± 0.13	.107	0.27	Small
ANTMED.RIGHT	0.84 ± 0.08	0.86 ± 0.08	.001*	0.13	Small
ANTMED.LEFT	0.86 ± 0.05	0.87 ± 0.06	.163	0.56	Moderate

§ Star Excursion Balance Test.
** Values whose changes between the pre-test and the post-test are significant T de Student. (p<0.05).*

Table 3. Comparison of means pre-test and post-test in SEBT§ score on Unstable Base Group (G2)

Variables	Pre -Test (mean ± SD)	Pre -Test (mean ± SD)	p value	Effect Size Value	Effect Size Difference
RIGHT FRONT	0.84 ± 0.05	0.87 ± 0.04	.001*	-0.10	Small
LEFT FRONT	0.86 ± 0.04	0.88 ± 0.03	.001*	-0.43	Small
ANTLAT.RIGHT	0.81 ± 0.09	0.82 ± 0.09	.057	-0.04	Small
ANTLAT.LEFT	0.80 ± 0.05	0.83 ± 0.05	.005*	-0.26	Small
LAT. RIGHT	0.76 ± 0.07	0.78 ± 0.09	.096	-0.24	Small
LAT.LEFT	0.76 ± 0.08	0.78 ± 0.07	.012*	-0.15	Small
POSTLAT.RIGHT	0.89 ± 0.05	0.91 ± 0.04	.017**	-0.17	Small
POSTLAT.LEFT	0.90 ± 0.05	0.91 ± 0.05	.494	-0.11	Small
POST.RIGHT	0.99 ± 0.03	1.01 ± 0.03	.014*	-0.35	Small
POST.LEFT	0.99 ± 0.04	1.01 ± 0.04	.027*	-0.19	Small
POSTMED.RIGHT	0.94 ± 0.03	0.96 ± 0.03	.000*	-0.16	Small
POSTMED.LEFT	0,95 ± 0.05	0.96 ± 0.05	.004*	-0.06	Small
MED.RIGHT	0.88 ± 0.03	0.90 ± 0.02	.002*	-0.06	Small
MED.LEFT	0.89 ± 0.03	0.90 ± 0.03	.151	-0.08	Small
ANTMED.RIGHT	0.88 ± 0.05	0.89 ± 0.06	.140	-0.18	Small
ANTMED.LEFT	0.88 ± 0.03	0.89 ± 0.02	.012**	-0.13	Small

§ Star Excursion Balance Test
** Values whose changes between the pre-test and the post-test are significant. T Student p<0.05*
*** Values whose changes between the pre-test and the post-test are significant. Wilcoxon p<0.05*

Table 4 shows the intergroup results before and after the training period, and we observe that in the variables ANTMED.RIGHT, the analysis conducted shows significant differences in the change occurred after the training period.

Table 4. Comparison of percentage changes in the Intergroup analysis.

Variable	G. Stable (mean ± SD)	G. Unstable (mean ± SD)	p value§	Effect Size Value	Effect Size Difference
RIGHT FRONT	0.72 ± 1.9	3.5 ± 2.1	.063	1.08	Large
LEFT FRONT	3.28 ± 1.3	2.45 ± 1.6	.111	0.22	Small
ANTLAT.RIGHT	0.84 ± 3.4	1.24 ± 2.0	.719	0.33	Small
ANTLAT.LEFT	2.94 ± 2.2	3.85 ± 3.0	.442	0.23	Small
LAT.RIGHT	3.04 ± 3.0	2.24 ± 3.8	.633	0.23	Small
LAT.LEFT	2.41 ± 3.6	2.88 ± 2.8	.860	0.15	Small
POSTLAT.RIGHT	1.09 ± 1.7	2.79 ± 2.6	.597	0.5	Moderate
POSTLAT.LEFT	0.9 ± 1.8	1.25 ± 4.9	.859	0.28	Small
POST.RIGHT	1.7 ± 1.2	1.81 ± 1.7	.600	0.05	Small
POST.LEFT	1.09 ± 1.5	2.09 ± 2.4	.535	0.54	Moderate
POSTMED.RIGHT	1.36 ± 1.8	2.47 ± 1.3	.241	0.50	Moderate
POSTMED.LEFT	0.49 ± 1.9	1.62 ± 1.2	.225	0.91	Large
MED.RIGHT	1.15 ± 3.3	2.44 ± 1.8	.211	0.62	Moderate
MED.LEFT	1.8 ± 3.1	1.05 ± 2.0	.799	0.39	Small
ANTMED.RIGHT	1.89 ± 1.3	0.93 ± 1.3	.046*	0.48	Moderate
ANTMED.LEFT	1.02 ± 2.0	1.84 ± 1.9	.384	0.50	Moderate

§ p values for the analysis of Covariance.
** Values whose changes between the pre-test and the post-test are significant (p < 0.05)*

DISCUSSION

The SEBT is considered a valid and reliable test to predict the risk of injury the lower limbs (Gribble, Hertel, & Plisky, 2012; Munn, Sullivan, & Schneiders, 2010; Plisky et al., 2006). Is also used as a training system in the process of retraining and rehabilitation of sports injuries of knee and ankle (Chaiwanichsiri et al., 2005), as well as a valid tool for assessing of chronics injuries recovery that affect the stability of those joints (Hale, Hertel, & Olmsted-Kramer, 2007).

Notably, many of the studies reviewed refer to subjects with articular pathology of the ankle or knee, or who are in the process of readapting to their sports activity (Chaiwanichsiri et al., 2005; Goetschius, Kuenze, Saliba, & Hart, 2013; Hale et al., 2007; Steib, Hentschke, Welsch, Pfeifer, & Zech, 2013). This work, however, was conducted with subjects that, as set out in the admission criteria, have not suffered any injury that has separated them from the working group for 2-3 sessions in the two weeks prior to the study, or do not suffer any chronic pathology at joint level.

Examining the results, it becomes clear that after the training program was conducted at proprioceptive level, there were improvements in terms of the distance covered in the different directions of the SEBT study (Hale et al., 2007; McLeod, Armstrong, Miller, & Sauers, 2009), as shown in Tables 2 and 3. It should be noted that there are not significant changes in all variables; however, it is important to stress the improvement in most of the variables. The effect size analysis determines that the changes will be small or, at most, moderate. In this regard it has been reported that proprioceptive training does not cause significant short-term improvements on the stability of the lower limbs (Romero-Franco et al., 2013).

There are a large number of variables that improve in the group that trained on an unstable base versus the group that trained on the stable base (Table 4). These differences are not statistically significant, so we cannot conclude categorically that one type of training is more effective than another. It should be noted that in variables RIGHT FRONT, POSTLAT.RIGHT, POSTMED.RIGHT, POSTMED.LEFT and ANTMED.RIGHT, although there are no important differences, the effect size was large relative to other variables. This could be due to the time of intervention applied and to the small number of subjects who were part of the sample when compared to other studies, where 30 subjects were studied (Demura & Yamada, 2010), 32 subjects (Chaiwanichsiri et al., 2005) or 235 (Plisky et al., 2006). Proprioceptive training using an unstable base improves balance, reducing the number of ACL injuries by 87% and reducing the risk of joint damage by 7 times (Morgan & Oberlander, 2001). Proprioceptive training, therefore, improves joint instability, which is considered one of the factors potentially damaging to the joints of the musculoskeletal system (Bahr & Krosshaug, 2005). In this sense, the results suggest that there are improvements concerning joint injury prevention, greater distance covered in the test indicates a greater ROM, therefore the greater the distance covered in each movement, the greater the joint stability, with, consequently, less risk of injury (Demura & Yamada, 2010; Filipa, Byrnes, Paterno, Myer, & Hewett, 2010; Kinzey & Armstrong, 1998; Plisky et al., 2006). On the contrary, lower results regarding postural stability indicate higher risks of joint injury (McGuine & Keene, 2006; Plisky et al., 2006).

We should highlight the influence the length of the leg has on covering more or less distance, and as discussed in previous studies, it should be taken into account when performing the SEBT (Gribble & Hertel, 2003).

There are authors that, in addition to highlighting the proprioceptive program as a key element in injury prevention, assert that it affects training in other areas, such as strength training of the muscle inserted into the joints, coordinative training, and training of the lumbo-pelvic belt (Krist, van Beijsterveldt, Backx, & de Wit, 2013; Mandelbaum et al., 2005; O'Driscoll, Kerin, & Delahunt, 2011). This posits that there are improvements in joint stability, so as a result, the number of sports injuries can be reduced, though not exclusively due to training at proprioceptive level, Therefore, the implementation of other types of content, as stated above, facilitates success in the implementation of a joint prevention program (Alentorn-Geli et al., 2009; Chappell & Limpisvasti, 2008; Gilchrist et al., 2008).

CONCLUSIONS

The results show that both training programs, on a stable and an unstable base, produce improvement in the values attained in the SEBT between pre-test and post-test, after the proprioceptive training program. After the training program was conducted for 5 weeks, no significant differences between the unstable base training and training stable base regarding improvement in balance and stability was found in this soccer team.

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