Original Article

Analysis of the effectiveness of the use of instep weights (Powerinstep) in everyday runners

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ABSTRACT

The use of weights when training is very common, especially in compensatory work and in performing supplementary exercises. A new type of weight appeared in the market in 2015 with the name of Powerinstep. It is a weight placed on the instep of athletes running shoes (Padullés & Rius, 2015). The goal of this study was to analyse the effectiveness of the use of these weights (Powerinstep) regarding the effect of biomechanical and certain athletic performance variables on two everyday runners groups with similar training methods. The sample used was composed of 19 subjects (9 male and 10 female). The control group (without weight) was made up of 4 subjects and the experimental group had 15 subjects (4 had 50-gram weights on each foot, 5 had 100 grams on each foot, and 6 had 150 grams on each foot). The weight given to each athlete depended on their body weight. There was a pre-test and a post-test done to each athlete with a training period of 14 weeks in between. These tests were: the Bosco test (SJ, CMJ, and ABK) and the Léger test (UMTT). The analysed variables were: height (cm) in SJ, CMJ, and ABK; time (s) in the Léger test; maximum and average heart rate (bpm); contact, flight, and passing times (s) of both left and right feet; step length (m) both left and right feet; stride length (m); the elevation of the centre of mass (cm) during left and right steps and the strides. Both the experimental group and the control group trained under the same time

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and schedule conditions, with the same work volume, and used the same training system. The only thing that varied between the groups was the whether they used weights or not. Given the sample characteristics, the statistical analysis method was non-parametric (Wilcoxon test). A comparative analysis of the variations between the pre-test and the post-test was done, both in the intergroups (control vs. experimental) and the intragroups (between the 3 subgroups of the experimental group). The differences found in the variations of the control group were not statistically significant ($p<0.05$). Neither were they in comparing the variations of the intragroups between the subgroups of 50g, 100g, and 150g weights ($p<0.05$). With this, it can be deduced that the weights given to each athlete regarding their body weight were correct. Statistically significant differences were found in the variations of the experimental group regarding the length of the stride ($p=0.05$), increasing this one, as well as the length of the left step ($p=0.04$). However, it has to be taken into account that the length of the step can be considered an improvement, but only if it is regulated to fit each athlete's ideal step length in relation to their trochanteric length, and if it is also associated with an increase of their driving force. Likewise, given the limitations of the sample for significant changes to be given over time, tendencies of the changes in the average percentages were analysed. Even if they did not offer statistically significant differences, they did offer results to take into consideration. This way, variations with higher percentages were found, and they were technically positive for the experimental group in 12 of the 18 analysed variables. The most noteworthy ones were: SJ (increase in the height of the flight (5.99%), Léger test (increase in the time (5.78%), length of both right and left steps (increases 5.99% and a 10.85% respectively), and the length of the stride (increases 8.11%). **Key words:** INSTEP WEIGHTS, POWERINSTEP, RUNNERS, BOSCO TEST, LÉGER TEST (UMTT).

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INTRODUCTION

The use of weights when training is very common (belts, vests, anklets, bracers, etc.), especially in compensatory work and in performing supplementary exercises (Tous, 1999). However, it is not common when realizing long sets. A new type of weight appeared in the market in 2015 with the name of Powerinstep (Padullés & Rius, 2015) (Figure 1). It is a mobile weighting set, consisting of three components: (1) a weight mount which is placed on the instep of athletes' running shoes, secured by it being tied between the shoe laces and the shoe tongue, (2) various weight capsules (50g, 100g, 150g, 200g) all of them being able to be anchored on the mount and instantly liberated from it, and (3) a belt with two weight mounts incorporated in order to allow instant weight installation and liberation from the instep to the belt.

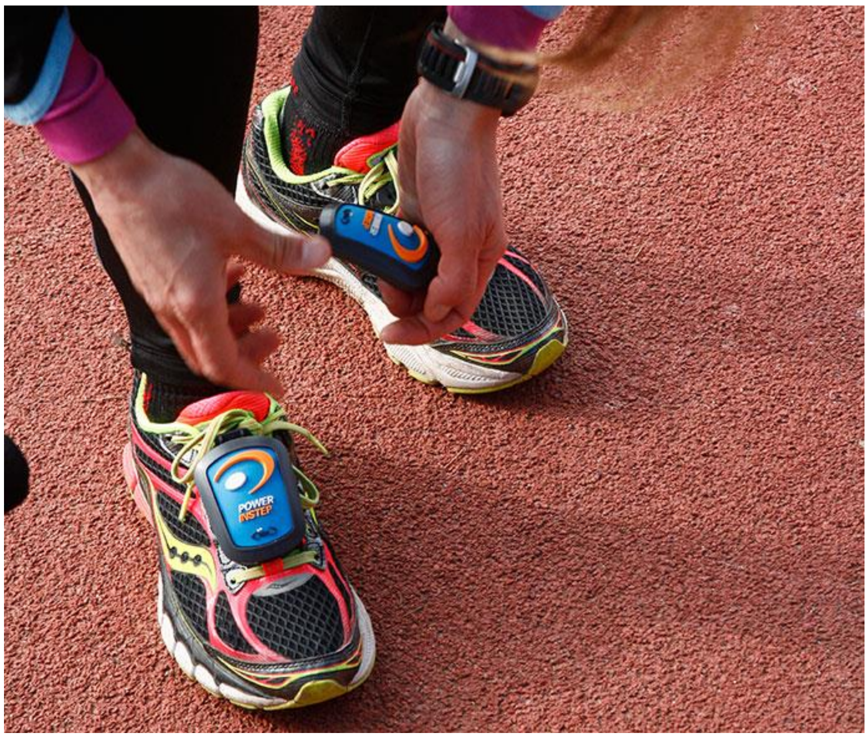

Figure 1. Placement of the instep weight.

The goal of this study was to analyse the effectiveness of the use of these weights (Powerinstep) in long sets, regarding the effect of biomechanical and certain athletic performance variables on two everyday runners groups with similar training methods. The instructions for the use of these weights were given by the manufacturer of this training method.

This investigation is the first in literature to study the effects of instep weights on runners when training long-distance sets, which reflects its originality.

MATERIALS AND METHODOLY

Sample

The initial sample was composed of 34 subjects (20 men and 14 women). Nonetheless, from the first test and throughout the training period, 15 subjects backed out, mainly because of muscular injuries (tibialis, calf muscles, and soleus), but also because of accidents or having stopped training. For this reason, the final sample used was composed of 19 subjects (9 male and 10 female). The group of men aged between 35 and 50 years of age and had a weight of 76.2 ± 10.18 kg; the women were aged between 33 and 57 and had a weight of 61.1 ± 9.46 kg. This sample was divided into an experimental group and a control group. The control group (without weight) was made up of 4 subjects (21,05 %) and the experimental group (78,95 %) had 15 subjects (4 had 50-gram weights on each foot, 5 had 100 grams on each foot, and 6 had 150 grams on each foot) (figure 2). The weight given to each athlete depended on their body weight. All the athletes of the experimental group also used the belt in all trainings.

All participants were everyday runners in good physical shape that trained at least three days a week and had at least two years of experience. All subjects accepted participating in the study voluntarily, having been informed beforehand about the aim, the nature, and the risks of the study, as well as the tests that would be performed on them.

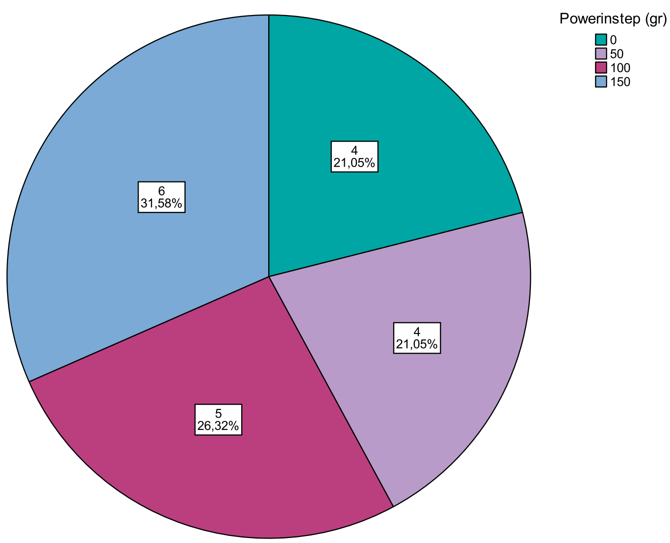

Figure 2. Distribution of the sample depending on the weight of the instep weights used in the training sessions.

Materials

For measuring

- Chronojump System 1.6 (©Chronojump Bosco System) with a Chronopic 3 with a contact platform DinA2 (Creative Commons) to control the vertical jumps of the Bosco test.
- GPS watch and heart rate monitor Ambit3 by ©Suunto Oy 10/2012, for controlling the heart rate throughout the track tests (Léger test).
- 4 Casio EX F1 cameras (Casio computer, Co. Ltd., Japan), on Manfrotto tripods, two of which record in high speed at 300 Hz (640 x 480 pixels), and two others which record in high definition at 30 Hz (1280x720 pixels), to obtain respective data referring to time and distance. The cameras were placed on the grandstand perpendicular to the main lane at a height of 1m. The data was recorded only with two cameras, one high-speed, and the other high definition. The use of the other two cameras was programmed only as a precaution just in case one of the cameras failed or a human error caused the recording to fail.
- Analysis software of the Kinovea v.0.17.10 image for the kinematic analysis of the run.

The subjects that were not from the control group performed the training sessions with the Powerinstep system of ©Cifosport Licensing S.L. with weights of 50, 100, or 150 grams in each foot, depending on the subject.

The calibration of the space in the track was done by measuring a 6m x 1.22m rectangle in lane 1 (the one in which the subjects ran) with white 5cm wide markers which were placed at every meter.

Also, in the pre-test, 2 halogen spotlights were used to improve the visibility in the 6 m section that was analysed. These spotlights were not necessary in the post test since there was more natural light at the time they were carried out.

PROCEDURE

There was a pre-test and a post-test done to each athlete with a training period of 14 weeks in between. The study started with an initial test (February of 2016), where the runners did a part of the BOSCO TEST (SJ, CMJ, ABK) (Bosco, 1994) and the LÉGER TEST (UMTT) (Léger & Boucher, 1990) in this order. This first test (or pre-test) was done right before starting the intervention and none of the runners had used instep weights before. For the realization of these tests, the athletes did not use the instep weights. The second test (or post-test) was carried out in June of 2016.

The Léger Test (UMTT) on the track is widely accepted by coaches and researchers (Ahmaidi et al., 1992, García, et al. 2013). An audible signal is let out to set the race pace, the speed is increased every so often, there are no pauses, and fatigue is reached. Additionally, it is recommended as one of the best tests for predicting VO_2 max on the field, given its low standard error of estimation and its height correlation with the measured VO_2 max (Léger and Bouchard, r=0.96).

The Léger Test (UMTT) was performed on the athletics tracks of the University of Barcelona, 400m track. The initial speed was of 8 $km \cdot h^{-1}$ and was increased by 1 $km \cdot h^{-1}$ every 2 minutes. The pace was set by an audible signal. There were markers placed every 50 metres so the subject would be able to regulate their speed to the one imposed by the signals. The test ended either when the subject stopped due to fatigue, or when the subject did not arrive to the 50m mark within the sound of the "beep" two times in a row. The subjects were cheered on in order for them to give their maximum effort.

In each of the Bosco tests, the subjects had two consecutive opportunities, counting the best jump in relation to the height of flight achieved. All those jumps that were not executed correctly, without following the required protocol were nullified.

In the Léger Test, two cameras recorded the steps of the subjects, lap after lap in the 6m long section calibrated on the track (Buscà, Quintana & Padullés, 2016). Out of each time they passed, two consecutive steps were analysed, one with the impulsion of each foot. For the final analysis, the data of each of the subject's fastest lap was used, namely, the last one they were able to complete.

The analysis of the images with the Kinovea software was done by two independent experienced observers.

The analysed variables were 18: height (cm) in SJ, CMJ, and ABK; time (s) in the Léger test; maximum and average heart rate (bpm); contact time, flight time, and step time (s) of both left and right feet; step length (m) both left and right feet; stride length (m); the elevation of the centre of mass (cm) during left and right steps and the strides.

The training program was based on the Powerinstep method standards, where percentages were applied for each subject and their level according to the instep weights. The subjects were randomly allocated into two groups: the experimental group, where the subjects trained with Powerinstep weights of 50g, 100g, or 150g; and the control group, where the subjects trained without weights.

The 14-week training program included 3 weekly sessions aimed at the improvement of aerobic capacity and power. It is the track test of Léger (UMTT) that was done, which is incremental, continuous and maximum, that measures the subjects' maximum aerobic power. After the 14 weeks of training, both tests were repeated at the end of the study (June of 2016).

Each session included first the warm-up (continuous run and strength or technique), then the main part of the training (interval, fractioned, or variable continuous run), and lastly the cooling down with stretching exercises. The training sessions were all carried out outdoors, either in the park of the Ciudadela or in the Passeig Marítim of Barcelona. The training was programmed with the aim of preparing for a 10km race; therefore it was intended to improve the aerobic capacity and power of the subjects. The use of a training program with the instep weights also aimed to improve running technique and vertical jump capability (this implied an improvement in explosive and elastic-explosive strength, with or without the use of the arms).

The programming of the 14 weeks of training included 3 weekly training sessions aimed at the improvement of the aerobic capacity and power. The Léger Test (UMTT), which is incremental, continuous, and maximal, measures the maximum aerobic power of the subjects.

The three weekly training sessions were distributed the following way:

- Monday: continuous run + running technique, short/medium intense interval training method, return to rest.
- Wednesday: continuous run + body weight strength, fractioned training method, return to rest.
- Saturday: continuous run, variable continuous or harmonic continuous methods, return to rest.

Every two weeks, the volume was increased until the two weeks before the last test. The ratio was of three weeks of higher training load and one week of recovery (lower training load). During the training sessions, the running pace, the exercise and recovery time, and the execution technique of the subjects were controlled.

Throughout the first four weeks, the subjects with the weights trained with them on one of the three weekly training sessions (Monday). During the nine weeks after, the subjects trained two of the days with the instep weights (Monday and Saturday). The last week, they trained without weights.

The weights were used during the warm-up (only in the continuous run), throughout the first two weeks. From the third week on, the weights were always used during the main part of the session (in a 30%-40% since the use of them was alternate, with and without weights). During the periods without weight on the instep, the runners always used the Powerinstep belt so that they didn't have to carry the weights with their hands while running outdoors.

The intensity was lower the first two weeks and the subjects worked with change in altitude. The volume was slightly increased at weeks three and four, training on flat surfaces and with changes in altitude. During weeks five through 8, there was a small increase in volume (capacity training sessions), but a higher increase in the intensity (power training sessions). For weeks nine through twelve, the volume of both capacity training sessions and power training sessions was increased, trying to maintain the improvement achieved throughout the four weeks of the increase in intensity. The two last weeks, the volume decreased drastically, maintaining the intensity until the execution of the third and last test.

Both the experimental group and the control group trained under the same time and schedule conditions, with the same work volume, and used the same training system. The only thing that varied between the groups was the whether they used weights or not.

RESULTS AND DISCUSSION

A comparative analysis of the variations between the pre-test and the post-test was done, both in the intergroups (control vs. experimental) and the intragroups (between the 3 subgroups of the experimental group).

The following tables present the different variables for the athletes in test 1 (pre-test), and test 2 (post-test), and compare the control group (table 1) and the experimental group (table 2).

Table 1. Indicates the different variables of test 1 and test 1 in the control group.

Variables		N	Mean	SD	Min.	Max.	50 (Median)
Control	SJ 1 (cm)	4	21	3,94	16,3	26	20,94
	CMJ 1 (cm)	4	23,2	4,38	18	28,47	23,33
	ABK 1 (cm)	4	27,3	7,03	21	37,29	25,46
	Time Léger 1 (s)	4	748	180,2	509	946	768,5
	HR max 1 (bpm)	4	184	13,74	171	198	183
	HR mean 1 (bpm)	4	160	14,61	140	173	162,5
	Ct right 1 (s)	4	0,27	0,011	0,26	0,28	0,275
	Ft right 1 (s)	4	0,09	0,028	0,06	0,12	0,078
	Step length right 1 (m)	4	1,39	0,219	1,19	1,7	1,34
	Ct left 1 (s)	4	0,26	0,015	0,25	0,28	0,258
	Ft left 1 (s)	4	0,07	0,019	0,05	0,09	0,063
	Step length left 1 (m)	4	1,33	0,196	1,16	1,54	1,31
	Step time right 1 (s)	4	0,36	0,02	0,33	0,38	0,359
	Step time left 1 (s)	4	0,33	0,022	0,3	0,35	0,336

	Stride length 1 (m)	4	2,72	0,402	2,35	3,24	2,65
	Elevation com right 1 (cm)	4	0,95	0,632	0,44	1,85	0,76
	Elevation com left 1 (cm)	4	0,58	0,34	0,27	1,06	0,49
	Mean stride elevation com 1 (cm)	4	0,76	0,485	0,36	1,46	0,63
	SJ 2 (cm)	4	21,5	3,7	16,8	25,21	22,1
	CMJ 2 (cm)	4	22,2	5,1	15,9	28,06	22,5
	ABK 2 (cm)	4	25,3	5,9	17,7	31,74	25,9
	Time Léger 2 (s)	4	733	152,1	582	906	723
	HR max 2 (bpm)	4	181	7,7	172	190	180
	HR mean 2 (bpm)	4	160	12,1	142	168	165
	Ct right 2 (s)	4	0,27	0,017	0,25	0,287	0,278
	Ft right 2 (s)	4	0,08	0,02	0,06	0,106	0,081
	Step length right 2 (m)	4	1,44	0,135	1,26	1,56	1,48
	Ct left 2 (s)	4	0,27	0,018	0,25	0,294	0,27
	Ft left 2 (s)	4	0,07	0,019	0,05	0,09	0,075
	Step length left 2 (m)	4	1,44	0,14	1,3	1,64	1,42
	Step time right 2 (s)	4	0,35	0,018	0,34	0,376	0,352
	Step time left 2 (s)	4	0,34	0,029	0,3	0,36	0,357
	Stride length 2 (m)	4	2,89	0,27	2,56	3,2	2,9
	Elevation com right 2 (cm)	4	0,84	0,41	0,38	1,378	0,8
	Elevation com left 2 (cm)	4	0,67	0,33	0,3	0,993	0,7
	Mean stride elevation com 2 (cm)	4	0,76	0,28	0,59	1,185	0,63

Table 2. Indicates the different variables of test 1 and test 2 in the experimental group.

Variables		N	Mean	SD	Min.	Max.	50 (Median)
Experimental	SJ 1 (cm)	15	19,2	5,3	11,8	29,1	18
	CMJ 1 (cm)	15	20,2	6,4	12,1	34,7	18,1
	ABK 1 (cm)	15	24	7,8	14,6	42,6	21,1
	Time Léger 1 (s)	15	692	181	453	1124	660
	HR max 1 (bpm)	15	183	13,7	163	211	184
	HR mean 1 (bpm)	15	159	12,2	138	180	158
	Ct right 1 (s)	15	0,24	0,03	0,19	0,29	0,23
	Ft right 1 (s)	15	0,1	0,05	0,04	0,21	0,11
	Step length right 1 (m)	15	1,39	0,26	0,96	2,07	1,4
	Ct left 1 (s)	15	0,23	0,03	0,19	0,29	0,223
	Ft left 1 (s)	15	0,09	0,03	0,03	0,13	0,1
	Step length left 1 (m)	15	1,33	0,2	0,91	1,65	1,32
	Step time right 1 (s)	15	0,34	0,05	0,26	0,47	0,34
	Step time left 1 (s)	15	0,32	0,02	0,29	0,36	0,326
	Stride length 1 (m)	15	2,72	0,43	1,87	3,57	2,73
	Elevation com right 1 (cm)	15	1,49	1,37	0,23	5,41	1,4
	Elevation com left 1 (cm)	15	1,17	0,61	0,13	2,17	1,22
	Mean stride elevation com 1 (cm)	15	1,33	0,9	0,27	3,35	1,35
	SJ 2 (cm)	15	20,5	6,8	10,7	33,1	19,7
	CMJ 2 (cm)	15	20,9	6,9	10,9	33,4	19,5
	ABK 2 (cm)	15	24,4	7,4	13,9	38,2	22,8
	Time Léger 2 (s)	15	709	135	470	945	692
	HR max 2 (bpm)	15	179	11,6	160	200	177
	HR mean 2 (bpm)	15	157	12,9	130	179	158
	Ct right 2 (s)	15	0,24	0,03	0,2	0,29	0,243

	Ft right 2 (s)	15	0,09	0,03	0,04	0,16	0,093
	Step length right 2 (m)	15	1,45	0,18	1,14	1,75	1,45
	Ct left 2 (s)	15	0,24	0,03	0,18	0,3	0,234
	Ft left 2 (s)	15	0,09	0,03	0,04	0,13	0,09
	Step length left 2 (m)	15	1,46	0,19	1,12	1,76	1,45
	Step time right 2 (s)	15	0,33	0,03	0,29	0,38	0,333
	Step time left 2 (s)	15	0,33	0,02	0,28	0,37	0,326
	Stride length 2 (m)	15	2,91	0,38	2,26	3,5	2,9
	Elevation com right 2 (cm)	15	1,16	0,8	0,22	3,13	1,06
	Elevation com left 2 (cm)	15	0,99	0,56	0,22	2,07	0,99
	Mean stride elevation com 2 (cm)	15	1,07	0,65	0,24	2,27	1,1

As it has been said, the data was obtained in two different moments. When analysing the distributions of the variables it can be seen that some do not follow a normal distribution. To compare two related samples with a variable that does not follow a normal distribution, the Wilcoxon test is used. This, and having a low 'n' value, will imply using non-parametric statiscal analysis methods (instead of working with values, it works with the order and the count, assigning ranks to the values without giving importance to the distribution).

A table is obtained that presents the average rank that the subjects have achieved on the days the test was done. It is observed that the average of the positions occupied on the first day, is in some cases higher and in others lower than on the second day. Thus, it is observed that the change is significant for the cases of the experimental group in the following variables:

Step length (m) with the impulsion of the left foot and stride length (m), are both significant increasing in both cases ($p<0.05$).

Maximum heart rate (bpm) and the time of contact of the left foot (s) are almost significant ($p = 0.069$ and 0.053 respectively), decreasing in the first variable and increasing in the second one.

However, there are no significant differences observed between the pre-test and the post-test in either of the variables in the athletes of the control group.

Figures 3 and 4 (box plot) show the cases where the values of the medians are significantly different between the before and after of the experimental group.

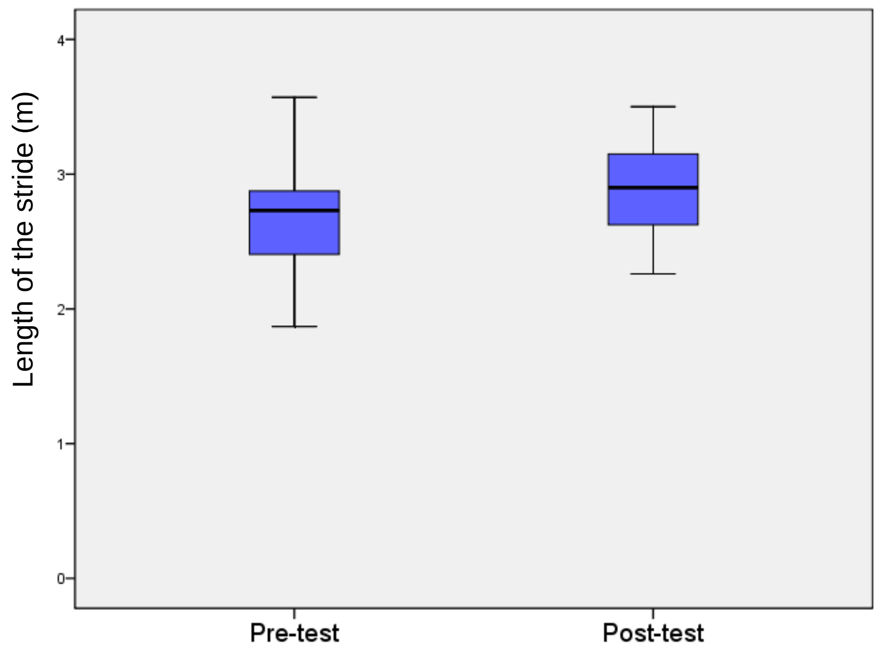

Figure 3. Box plot graph shows pre- and post- Length of the stride.

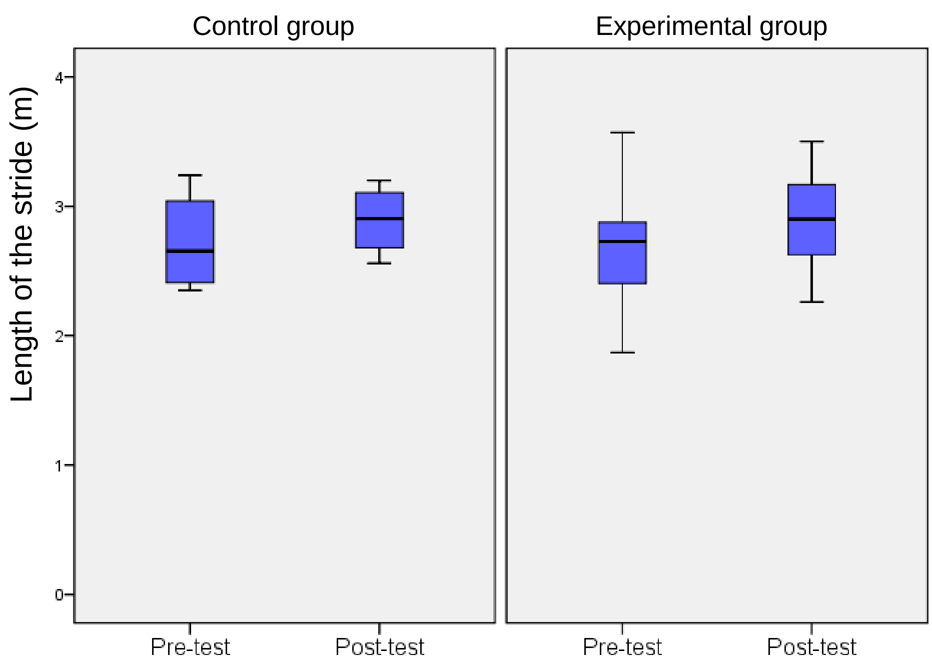

Figure 4. Distribution of Length of the stride by the control and the experimental group.

Maintaining the same analysis but applying a parametric test (to visualize the values of the averages), and ANOVA is carried out with repeated measures, specifically a two-factor model with repeated measures in one factor.

A factor (time) with two levels (the two times measures were registered: test 1 and test 2) and a dependent variable (the variable that is being evaluated). Since all subjects were recorded both times, it is a factor of repeated measures, and therefore related samples are being dealt with.

In the results, it can be observed that the factor of time between the pre-test and the post-test is not significant, nor is the interaction with the type of group. In other words, the values of the variables in test 1 are very similar both times as it can also be seen in the tables.

As in the previous results, it is only in the variable of the length of the stride 1 and 2 where there are significant differences between the pre and the post tests.

In relation to the inter-subject factor, the type of group, in some cases the value of p was of <0.05 and so the null hypothesis can be rejected. Therefore it can be concluded that the group factor is significant because the values differ significantly between the 4 groups. In the majority of the variables, the difference is found within the 150g and between the 50g and 100g. However it has to be highlighted that this could be interpreted incorrectly because men (150g) and women (50 and 100g) are also being compared.

After completing the statistical analysis of the results, in the intergroups (control vs. experimental), statistically significant ($p<0.05$) differences were not found when comparing the changes produced in 16 of the 18 analysed variables between the control group and the experimental group.

Statistically significant differences were found in the variations of the experimental group regarding the length of the stride ($p=0.005$), increasing this one, as well as the length of the left step ($p=0.004$). However, it has to be taken into account that the length of the step can be considered an improvement, but only if it is regulated to fit each athlete's ideal step length in relation to their trochanteric length, and if it is also associated with an increase of their driving force. Likewise, the athlete's displacement velocity has to be at an optimal combination between step length and frequency. Therefore, this simply shows that there has been a statistically significant increase in the length of the stride when comparing the increases of the control group and the experimental group referring to this variable. This does not necessarily mean that it is going to be something positive for the athlete.

The significant differences in the step length with impulsion of the left foot can be misleading and could be due to chance instead, for not having done specific one-foot work nor asymmetric training sessions to improve the results of the left limb in comparison to the right.

Regarding the analysis of the intragroups, the differences found in the variations of the control group were not statistically significant ($p<0.05$). Neither were they in comparing the variations of the intragroups between the subgroups of 50g, 100g, and 150g weights ($p<0.05$). With this, it can be deduced that the weights given to each athlete regarding their body weight were correct.

Likewise, given the limitations of the sample for significant changes to be given over time, tendencies of the changes in the average percentages were analysed. Even if they did not offer statistically significant differences, they did offer results to take into consideration. This way, variations with higher percentages were found, and they were technically positive for the experimental group in 12 of the 18 analysed variables. The most noteworthy ones, when comparing the pre-test and post-test were: SJ (increase in the height of the flight 5.99%), Léger test (increase in the time 5.78%), length of both right and left steps (increases 5.99% and a 10.85% respectively), and the length of the stride (increases 8.11%). For these same variables, the changes in the control group were of: 3.20%, -0-51%, 4.93%, 9.27%, and 6.89%. Nonetheless, emphasis has to be placed on the factors that determine an optimal step and stride length, and it cannot be forgotten that the SJ test fundamentally values the explosive strength of the lower limbs, even though during the training of the subjects, no specific work was done to improve explosive strength using the instep weights.

On the other hand, even if there were no quantitative results obtained in relation to the dorsal flexion of the foot, it has been observed qualitatively that the use of instep weights favours this dorsal flexion of the foot when running with them. This will then also favour the reactive action of the foot when in contact with the floor if the speed of the descent of the foot is increased at the same time.

CONCLUSIONS

A part from the variable of stride length ($p<0.05$), statistically significant differences were not found when comparing the differences or changes between the pre-test and post-test of the control group and the experimental group; neither when analysed separately nor compared to one another.

The sample is small to extract definite conclusions, which is why studies with bigger samples should be carried out from this investigation. Also, it is recommended to analyse the effects of the use of instep weights on specific running technique exercises, open chain toning exercises, and joint mobility exercises, rather than in performing long-distance sets as it has been done in this case.

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