Short-term influence analysis of different instep weights on 50 meters speed and running time

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Conflicts of interest

All authors declare that they have no conflicts of interest.

Abstract

Instep weights cause mechanical changes, modifying muscle activity and changing ground plantar support. 30 semi-professional sprinters, randomized in 3 groups [no-weight, Ascending (50, 100, 150 and 200g), Descending (200, 150, 100 and 50g)] run 6 consecutive 50-meter series at maximum speed (first and sixth without weights); partial, total times and speed were analyzed. Instep weights were safe and well tolerated. 6th series speed decreased except in men's ascending group, who achieved a lower time in sixth compared to first series. Weights presented in ascending order in men during warm-up could improve running time. Instep weights neuromuscular effects could compensate men's tiredness in last series; weights could be included in training methodologies. Men training weights presented in ascending order may provide better results.

Keywords

Keywords: Locomotion; Motor Control; Muscle Synergies; Physiology; Running.

Introduction

Several studies show wearable resistance (load or weight) training effects with a variation of loads placing.[1] Macadam et al. highlights metabolic parameters variations with trunk loading (VO2, exercise intensity and heart rate, HR); only HR 6.9-7.7% variation increases significantly with 20-40% of Body Mass (BM) body loads.[2] Other studies show maximum velocity decreases with 5-21.8% BM on sprint performance (Macadam et al., 2019) with linear descending patterns (3.6-11.7%) when loading excess 9% of BM.[3] Regarding step parameters, trunk loading in 50-meters-sprint performance results in a significant step length decrease (-4.4%) and significant increases in contact time phase at the expense of swing phase with loads between 11-21% of BM.[2,3]

Depending the position of the wearable resistance on the limb, the muscle overload can be modulated. It is possible to increase the inertia of the lower limb by moving the load proximally-distally on the rotation axis. Consequently, the mechanical work of certain joints can be increased, working more specific musculature.[4] Moreover, the load variability could be better intermuscular coordination. That thing could be influencing on sports performance and injury prevention.[5]

Some studies considering limb load effects show that armload increases step length but decrease stride frequency when surpassing 2% of BM.[3] Initial acceleration and speed improvements have been recorded.[3] On leg loads, evidence show biomechanical and kinematic changes heightened with more distal loads (ankle or food, compared to the thigh or shank) and consistent decreases in step frequency during sprints (3.5-3.6%).[2,3] Kinematics parameters as velocity decreases significantly with 0.6-5%BM loads.[2,6]

Changes (but in a lower proportion) also observed in tennis players were accuracy and change of direction speed is measured, probably due to lighter loads (0.33%) of BM. Feser et al. indicated, in a systematic review, that the micro-loading induced by wearable resistance studies completed to-date appeared to consistently affect some kinematic variables, such as step frequency and contact time, when the load was distributed along the lower limb. However, when an estimated 4.8% load was only situated on the end of the limb (at the ankle), the sprint velocity was significantly decreased and the stride lench was unaffected.[7] Using wearable loads may enhance stride frequency, resulting into a better agility performance.[8]

Extra weights inclusion during specific training exercise report improvements in biomechanical parameters and performance values.[9] Developing strength and resistance gains in specific running movements could cause better training-performance transference,[3,10] improvements also recorded in other sports as tennis,[8] based on performance changes including forces' direction (lateral and horizontal), unilateral propulsion, full range and speed performance, cyclic movements, and multi-planar field.[3] Several mechanical determinants that are overloaded by lower-limb wearable resistance may be influenced over time to produce positive speed adaptations.[11]

Plyometric training with additional body 10% load weight develops strength and neuromuscular efficiency.[12] In moderately trained health young men, body weights and sports activity (90% of maximum power output) combination allows, in the short-term, to increase jump height after jump squat training with individualized loads.[13] In addition, Asymmetrical shank resistance could be used during high-speed running to reduce or increase the kinetic loading of an injured/rehabilitative limb during return to play protocols.[14]

Instep weight use combined with running training changes race's mechanical parameters (horizontal-force velocity, impulse,[15] support time, suspension, flight time, frequency, step length), modifying muscle activity[16] and conditioning running biomechanical modifications and foot's plantar support on the ground;[17] feet support biomechanical modifications could reduce the risk of lower limb impairments produced by anomalous supports during the race.[8]

Preliminary studies using video-graphic measurement on a 1% slope treadmill showed step frequency significant increase (+0.96%), Ankle dorsiflexion and maximum Ankle dorsiflexion during the second gait phase or swing phase, from toe to heel floor contact, especially when using a 200gram (g) weight.[18]

In a small pilot test in triathletes (n=3) biomechanical parameters were analyzed during the race without instep weights and with 100g and 200g instep weights, on a 1% slope treadmill. Using 200g instep weights step frequency increased in a 0.96% (p=0.0225) and dorsal ankle flexion significantly reduced (right: -8.04%, p=0.0065; left: -18.7%, p=0.0176). Reception phase angle was reduced (-36.75% p=0.0649), reducing heels pressure and favoring mid-foot support. Modifying foot support biomechanics, instep weights could reduce lower limbs' alterations risks produced by anomalous supports during the race (Cos Morera et al., 2018b).[17]

With the same athletes in another pilot test, tibialis anterior muscle, quadriceps, and hamstrings electromyography activity during the race without instep weights and with 100g and 200g instep weights showed significant differences in all three muscle groups with the use of 100g instep weight (p <0.05) but not with a 200g weight. 100g weight use (or equivalent, according to each athlete's weight, height and sex) could modulate muscular instep loads in the workouts.[16]

In amateur runners performing a 14-week training program, López JL et al. concluded that participants who used instep weights attained a longer stride length (p=0.05) and longer left step length (p=0.04), compared with not using instep weight runners. Léger test results (related to VO_2 max) increased 5.78% after the weight program, while runners not using instep weights did not modify Léger test results.[18]

100g weight use (or equivalent, depending on individual athlete's weight, height, and sex) could modulate muscular load in the workouts.[16] Electromyography tibialis anterior, quadriceps and hamstring muscles changes show significant 6% and 8% increases in muscle activity, with average increase in CO_2 elimination (as metabolic waste) of 8-10% and in 1-2% O_2 consumption (VO_2).[2,16] Macadam et al. (2017) highlights an increase of 1.7-10.2% of VO_2 values with a lower body loading of 0.3-8.5% BM respectively, increasing VO_2 values as the load placed more distal. In addition, significant energy workload increases (9.1% for 0.5%BM and 19.7% for 0.7% BM) in foot-loads during treadmill running were found.[3] In addition, evidences show that Instep weights are safe and well tolerated as a warm-up technique in short distance runners[19] and in long distance training during several months.[20]

We hypothesize that using instep weights during pre-race warm-up is safe and well tolerated and could modify 50-meter run maximum speed performance in sprinters and hurdlers, and changes could be different between genders.

Methods

Subjects: 30 semi-professional active sprinter athletes from INEFC-Barcelona (17 women, 13 men; aged 13-32y.o., average= 20.28; minimum weight: 47.0, maximum: 89.0 kg, average=

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59.5 kg). Design: interventional study; after accepting the informed consent, each participant had to run 6 sets of 50-meter running with different instep weight weights of 50g, 100g, 150g and 200g respectively (or 1.76oz, 3.52oz, 5.29oz and 7.05oz). Subjects were randomized into three groups: Ctrl (Control Group: no weight use in any of the six series), Asc (Ascending Group: first and sixth series without weight, intermediate series with increasing weight weight of 50g, 100g, 150g and 200g respectively) and Desc (Descending Group: first and sixth series without weight, intermediate series with decreasing weight 200 g, 150 g, 100 g and 50 g, respectively). Methodology: weights were placed on the instep using the weight device attached with a clip grip to the regulatory athletes' spikes. Weight used: Power Instep®. Each participant ran six 50-meter series separated by a 15 minutes resting period, following the instep weight cadence according to his/her intervention group.

Variables: sex, age, intermediate and final times of every run were recorded using Witty Wireless Training Timer System® with gates every 10 meters (Microgate™, Italy), enabling the high accuracy registration of 10 meters-split partial times; qualitative questions about safety and comfort were added to the data collection form.

Statistical analysis: speed data of each series were analyzed and compared, as well as sex stratification; hypotheses were contrasted using t-test distribution (calculation with equal or unequal variances according to the results of the variable) with a 95% confidence interval with IBM™ SPSS® v.20 program.

Ethics: The Universitat Autònoma de Barcelona Research Ethics Committee (CEEAH-UAB) approved the study (No. 4987).

Results

None of the participants suffered injuries or reported notable discomfort during instep weights use. Total race time increased in all groups between the first and sixth series; in the Ctrl group race time increased by 8.5 milliseconds (ms) from a mean of 654.4ms in the first series (Standard Deviation, SD=31.92) to 662.9ms in the sixth series (SD: 35.02; p=.153); in the Asc group it increased by 6.0ms from an initial mean of 673.5ms (SD=36.05) to 679.5ms (SD=36.88) in the sixth series (p=.218); in the Desc group race times increased statistically significantly in 8.9ms from an initial mean of 652.5ms (SD=55.14) to 661.4ms (SD=61.26) in the sixth series (p=.018). Progressions between all groups different series are shown in Image 1. Comparing groups, differences are not significant between the increase in running time between the first and sixth series (Ctrl-Asc: p=.34; Ctrl-Desc p=.49; Asc-Desc: p=.30).

Total race time between first and sixth attempts increased in all groups. Analyzing participants separately by sex, men in Asc group *[see Image 2]* achieved a slightly lower time (higher speed) in the sixth race compared to the first; although this was not statistically significant (p=0.47) they tend to decrease their race time an average of 667ms (SD=19.03), while Desc and Ctrl men groups worsened (lower speed) 490ms (SD=13.76) their running time. Regarding women, in all groups race time was longer in the sixth race than in the first one with total average time of 10.985ms (SD=10.88). Men average speed comparing first and sixth attempts (both series without weights) tend to reduce in groups Desc and Ctrl, while in Asc group total time increased slightly but not significantly (p=0.48); in women all groups worsened their speed between races first and sixth.

Differences in baseline times between Asc and Ctrl or Desc could be caused by distinct men-women proportions in these groups (3:7 versus 5:5).

Dividing each of the six series into five partial 10-meter sections *[Image 3a-b]*, Asc men showed higher (better) intermediate speed in the sixth race than in the first one, in all partial measurements. In this group, partial sixth-race speeds (without weights) were always ascending, showing a constant linear acceleration until the final 10 meters section, in which acceleration always increases. Desc men invariably maintained their speed during the last 10 meters of the sixth race compared to the first race, while the remaining intermediate speeds were worse (slower). In Ctrl men, all partial speeds were lower in the sixth series than in the first one. In women, all partial times were longer (worse) in sixth series than in first one.

Analysing athletes according to the instep weight they were carrying (regardless of the groups to which they belonged), both in men and women the 50-meter race average speed was significantly worse. Therefore, the heavier the weight was, the worse their average speed was, and the average speed was lower in the last series compared to the first series (both without weights).

All athletes reported good tolerance and none of them suffered any injury.

Discussion

Time race results (Image 1) show how in the Ctrl group (without instep weight in any of the six series) time increases slightly with the course of the six series (8.5 ms), probably due to the accumulated fatigue in the participants, but nevertheless this increase was not statistically significant (p=.153). In the Asc group, a greater increase in running times can be observed as the series go on, and instep weights are added (from 50g in second race to 200g in fifth one), observing that in the last series the time is not significantly greater than in the first race (also without instep weight), showing a non-significant total increase of 6.0ms (p=.218); this increasing time is less in Asc group than in the Ctrl group. In reference to the Desc group, the same changes are observed as in Asc group but in the opposite direction, since weights started in decreasing order (from 200g in second race to 50g in fifth race) between series 2 and 5; in this group, the differences between series 1 and 6 (both without weight) are significant (p=.018) with an increase in running time of 8.9 ms between first and sixth series. These facts show that in pre-race training (warm-up), the use of instep weights in ascending cadence does not significantly increase race times compared to performing warm-up sessions without weights (p=.34). So, these results confirm that the use of instep weights in warm-up training prior to a sprint race (50 meters) does not significantly decrease sprinters' speed and that possibly the weights presented in ascending order causes a lesser decrease in speed between the first and sixth series comparing to the same series races without any weight. Although the differences are not significant, a trend can be observed in this regard.

Evidence shows a general significant decrease in maximum speed in short distance running series with any weighted load. Nevertheless, the times seem not to vary significantly. In this study, the non-significant statistically improvements obtained in the last series (without weight) after applying weights presented in ascending order reveals a limited effect of this warm-up technique. Despite that, in a maximum-speed performance context, these slight changes, even if they may seem numerically insignificant, can produce large changes in athletes’ final performance results.

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In general, this study results seem to be not statistically significant; moreover, the small change magnitudes observed can be considered transcendent in some elite sports contexts. These changes allow us to consider that the use of increasing weight instep weights in men during 50-meter warm-up series at maximum speed (previous to the training session or even previous to the competition) could slightly increase athlete's final race speed by decreasing the race time between the first and sixth attempts by a few hundredths of a second. These changes can be produced by different muscle stimulation,[16] and adjustments to positive biomechanical changes[17] occurred during warm-up, which would allow race parameters to be sufficiently modified to small but significant speed increase. Thus, instep weight use in ascending cadence in men during 50-meter race warm-up series would also allow partial speeds to slightly increase progressively in the sixth series (without weights) with a greater acceleration in the last 10 meters *[Image 3a-b]*.

Several scientific studies conducted with instep weights show positive effects on the race, due to the unique influence of their placement specifically on the instep (allowing full ankle's mobility) without neither decreasing inter-muscular coordination nor altering the running technique,[3,16,17,18] by positively modifying performance during workouts (technique, strength, speed, endurance). Likewise, instep weight use implies athlete's proprioception changes, helping those athletes who perform exercises in an automated way with an ineffective technique to improve it.[17]

Practical applications: The use of weights during the short race (50 meter) warm-up is safe and well tolerated by runners. The use of instep ascending weighted weights in the warm-up could improve the speed in short distance running, while not using weights or using them in a descending weighted pattern could worsen the results, both in a non-significant statistically way. Even though in a maximum speed performance context, these hundredths of a second changes may be relevant.

For maximum running speed, this study reflects that the use of instep weights is safe and well tolerated; in men and with weights presented in ascending order protocol during training or warm-up sprint series (increasing weights in a 50-100-150-200 g. weights pattern) it could positively modify their speed time in 50-meter speed races in sprinters and hurdlers, and it could provide higher training results. Larger studies are needed to endorse these results, as well as studies on the influence of instep weights over running training in different distances of races runners.

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Figures

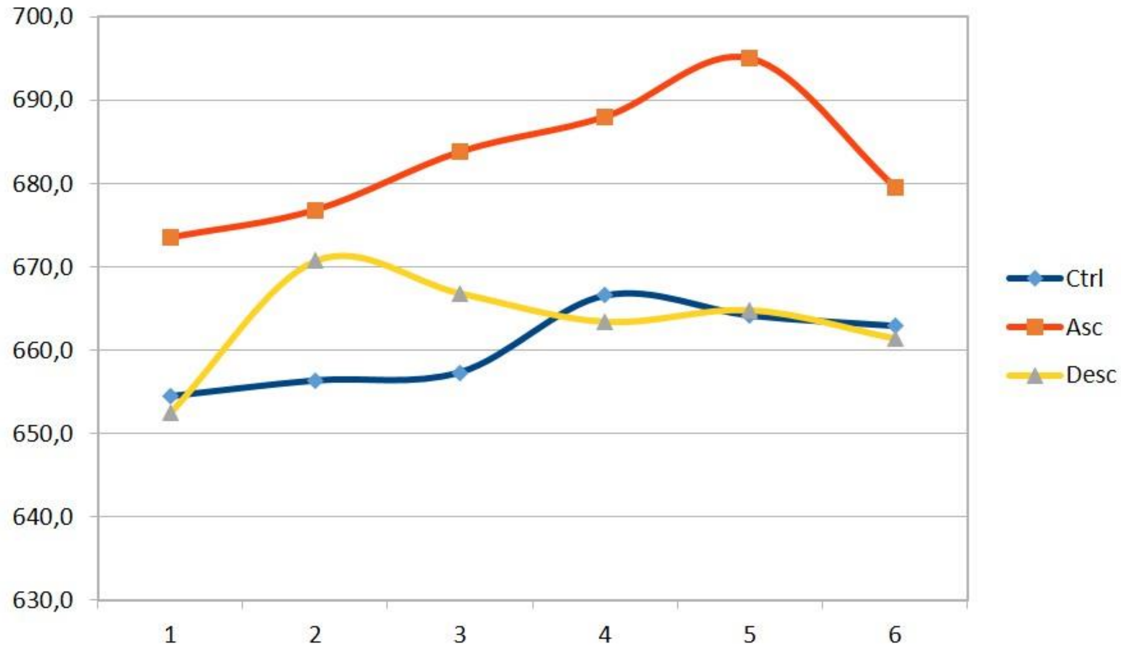
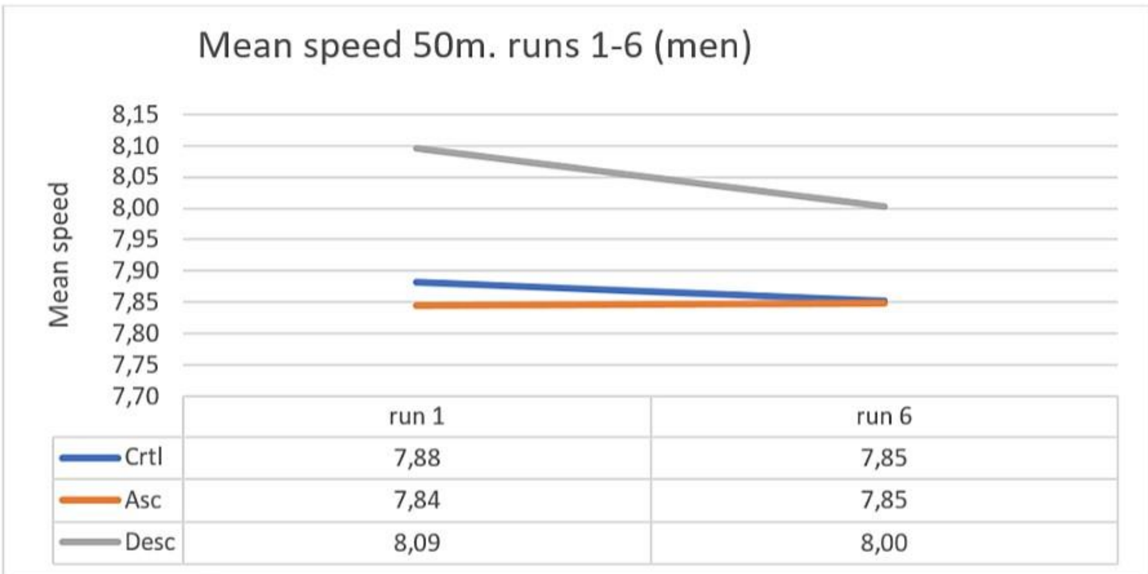


Figure 1. Average time of each series, separated by Ctrl, Asc and Desc groups.



Men	**p-value (runs 1-6)**
Ctrl	**0,2786**
Asc	**0,4871**
Desc	**0,0658**

Figure 2. Average men total speed of series 1 and 6, by groups.

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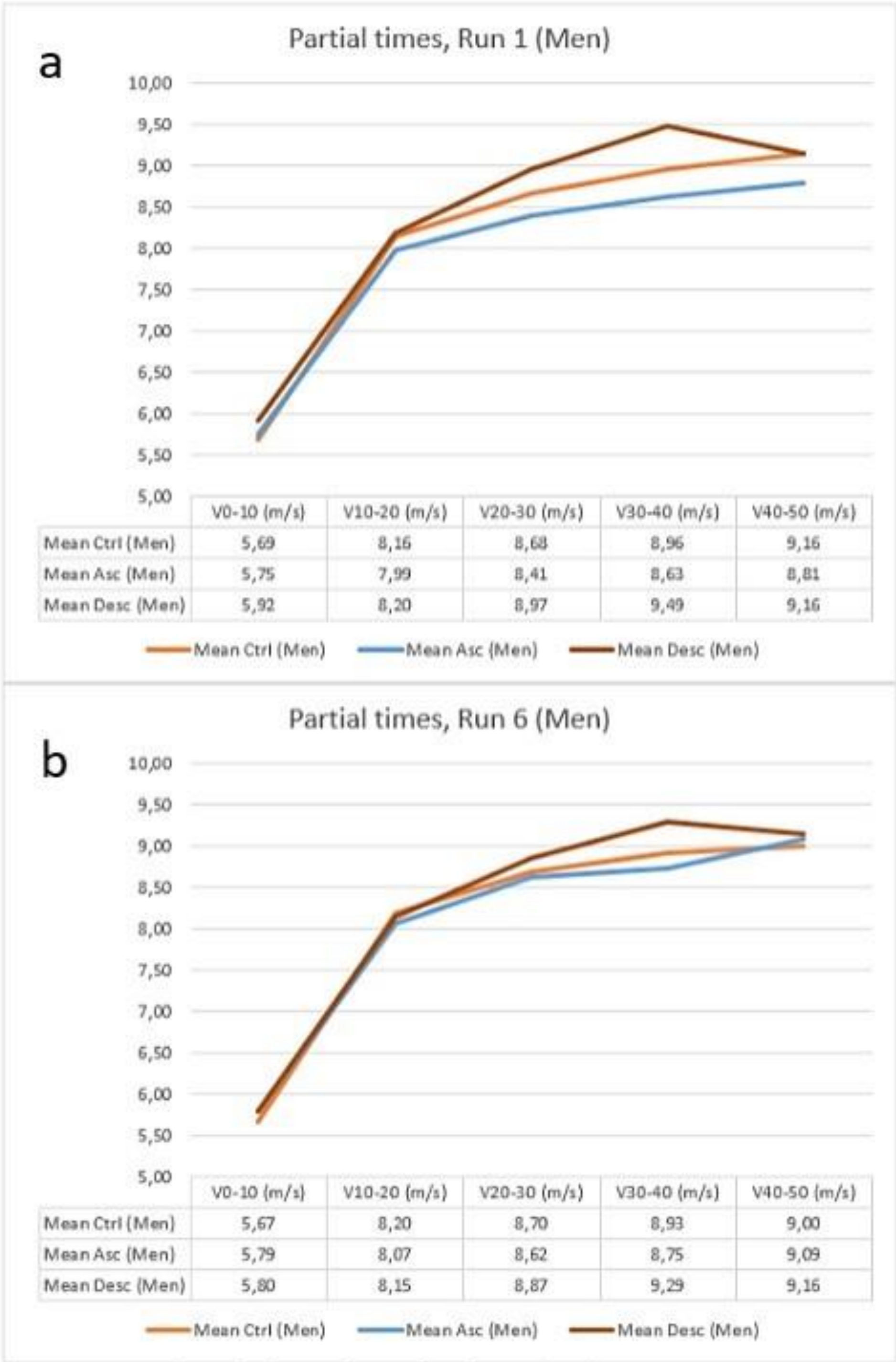

Figure 3. a- Partial men average times every 10 meters in first race, by groups; b- Partial men average times every 10 meters in sixth race, by groups.

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