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Original Article

The role of a check-mark in step length adjustment in long jump

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ABSTRACT

Makaruk, H., Starzak, M., & López, J.L. (2015). The role of a check-mark in step length adjustment in long jump. *J. Hum. Sport Exerc., 10*(3), pp.756-763. The purpose of this study was to examine the effects of utilizing a check-mark on step length adjustment in long jump. Twelve male non-skilled jumpers (age 22±0.9 years, height 1.74±0.09 m, body mass 69±9 kg) with 3 years athletics experience volunteered in this research. Using a within-participant design, participants performed six jumps in two conditions: with and without the check-mark. Footfall variability, and then step length adjustment during approach run (ten final steps) were evaluated by the calculation of the standard deviation (SD) of the toe-to-board distances for analogous step of the approach run across each subject's attempts. The Optojump Next (Microgate, Italy) was used in this study. Post hoc analysis showed that the footfall variability was significantly ($p<0.05$) different from 6th to 1st step from the board for both the approach run conditions. In addition, pairwise analysis indicated that the take-off accuracy was significantly ($p<0.05$) greater, and onset of step length adjustment was significantly ($p<0.05$) earlier in the check-mark conditions than seen in non-check-mark conditions. The low skilled athletes or those with inconsistent pattern of gait regulation should employ the check-mark on the run-way during their training and competitions. **Key words**: GAIT, VISUAL REGULATION, PERCEPTION, APPROACH RUN.

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INTRODUCTION

According to the rules of the International Association of Athletics Federations, a measurement of jump needs to be accomplished from the distal edge of a take-off board to the nearest mark in a sand pit made by an athlete. Therefore, it is widely believed that accuracy of the take-off is crucial in long jump. Rarely do athletes strike on the take-off board with the high accuracy (about 1-2 cm). The researchers found the average take-off accuracy (toe-distal edge of the board distance) was 11 cm for elite male long jumpers (Hay, 1988) or 8-10 cm for national top-class athletes in long and triple jump (Makaruk et al., 2015), while it was 25 cm for non-long jumpers (Scott et al., 1997) and 15 cm for novice (Berg & Greer, 1995) in long jump. In the last two cases only legal jumps were taken into consideration.

The question of how an athlete proceeds to accurately strike on the board arises. It has long been accepted that the participants who perform long jump adjust their step length before the take-off (Lee et al., 1982; Hay, 1988; Hay & Koh, 1988). The general conception about step length adjustment in horizontal jumps is that the variability of footfall placement (measured as standard deviation of toe-to-board distances for each step across all the jumps) gradually increases until about 5 steps from the take-off board. This the first phase of the approach run called the 'acceleration' phase. Then the variability of footfall placement significantly decreases until the take-off in the second ('zeroing-in') phase (Lee et al., 1982). It happens because some inconsistencies in step length are accumulated at first in the 'acceleration' phase, and they have to be reduced by adequate gait pattern to hit the board as accurately as possible. The researchers suggested that visual control is the key here (Lee et al., 1982; Hay, 1988; Bradshaw & Aisbett, 2006), but recently it has been found that other factors, like kinaesthetic or audial perception need to be taken into consideration in this regard (Berg & Mark, 2005; Theodorou & Skordilis, 2012).

Our latest study (Makaruk et al., 2015) revealed the length of the 'zeroing-in' phase (step length adjustment) phase is considerably distinct among top-class male and female long and triple jumpers. The shortest step length adjustment phase involved one step, the longest over ten steps. Previously, similar observations were confirmed by Hay (1988) who studied elite male and female athletes. It was also found (Makaruk et al., 2015) that the amount of footfall variability was different among athletes. These results were similar to those of Scott et al. (1997) in non-long jumpers. It may indicate that the gait regulation over the entire approach run as well as the step length adjustment are determined by individual skill each subject, but there is little evidence about its variability across different external conditions. Some data (Starzak & Makaruk, 2015) showed that step length adjustment skill in not stable for the same athlete and may show a different pattern depending on task, like athletics event (long jump vs triple jump). These observations have important implications for practice because may indirectly indicate coaches may influence step length adjustment by external conditions (constraints), and in this way to try to improve the athletes' accuracy during the take-off. Moreover, as the study showed the early step length adjustment resulted in a greater velocity during the last steps of the approach run compared to late step length adjustment in male horizontal jumpers (Makaruk et al., 2015) as well as the greater distance in long jump performance (Bradshaw & Aisbet, 2006).

In the light of above mentioned, using the coach's checkmark that is placed about 5-4 steps from the take-off board may be of crucial importance in providing adequate footfall variability and step length adjustment at proper distance before the take-off. To date, little attention has been focused on the optimization of step length adjustment by changing the external conditions, like coach's check-mark on the run-way for long jump. Greenwood (2014) demonstrated that the condition with board markers that were placed either side of the take-off board changed the footfall variability pattern of long jumpers during the approach run in comparison to the non-markers conditions. The board markers condition provides more consistent gait pattern (lower level of variability) across all steps of the approach run.

Therefore, based on Greenwood work (2014) and others (Hay, 1988; De Rugy et al., 2002), we hypothesized that utilizing the check-mark would improve the take-off accuracy by decreasing footfall variability and provide earlier step adjustment compared to non-check-mark conditions.

MATERIAL AND METHODS

Material

Twelve male non-skilled jumpers (age 22±0.9 years, height 1.74±0.09 m, body mass 69±9 kg) with 3 years' athletics experience volunteered in this research. The study was approved by the university ethics board. Informed consent was obtained from each subject.

Procedure

Participating subjects were tested in indoor athletics hall with daily light conditions. The experiment consisted of two testing sessions. Using a within-participant design, participants performed six jumps in two conditions: with the check-mark (CHM) and without the check-mark (NON). Two sequences of treatment were used (a. CHM-NON, b. NON-CHM) in a randomized counterbalanced order to avoid potential order effects. Testing session was separated by one week. Each testing session lasted about 80 minutes, including warm-up exercises. The warm-up consisted of a ten-minute jog, 8 minutes of dynamic stretching, skips and accelerations 4 x 20 meters. Following the warm-up, participants were given a passive rest period (3-6 minutes). They were also provided with a 6-minute rest between each jumping attempt. When participants performed jump in the CHM condition, they were told:"Jump as far as you can". In the NON condition, the instruction was "Jump as far as you can. The check-mark is placed on the run-way across these attempts". The white check-mark was square in shape and was 25 cm high, and 25 cm wide and was placed on the right line of the run-way. The distance of the check-mark from the board was set as 9 m (about five steps before the take-off) which was established in previous studies (Hay, 1988). All subjects were familiar with long jump performance as they had practised it during their classes over the first degree course. They were not provided with any feedback on their performance during the test. The reliability of task performance was assessed using intra-class coefficient (ICC). The ICC was high, between 0.90-0.96 for measured variables (step length, contact time, flight time).

Apparatus and Measurements

The Optojump Next (Microgate, Italy) is an optical measurement system that was used in this study. The system consists of 25 pairs of 1-metre transmitter and receiver bars placed parallel to each other on the run-way. Each bar contains 96 leds, positioned 0.2 cm above the ground with 1.04 cm resolution. The system detects any interruptions in communication between the bars with a timing accuracy of 1 ms. The following parameters were measured by the Optojump Next during the task: contact time was determined by the time period from foot touchdown to the take-off; flight time was determined by the time period from foot take-off to touchdown of the opposite foot; step length was determined as the distance from the tip of the spike-shoe at the take-off to tip of the opposite leg spike-shoe at the take-off, mean step velocity was determined as the ratio between the step length and the sum of the contact time of the pushing leg and flight time during this step.

Footfall variability during the approach run (ten final steps) was evaluated by the calculation of the standard deviation (SD) of the toe-to-board distances for analogous step of the approach run across each subject's attempts. The starting point of step length adjustment was identified as the point when SD of toe-to-board systematically decreased until the take-off (Bradshaw & Aisbet, 2006). Both legal and foul jumps were included in the analysis.

The following dependent variables were involved in the study: maximum footfall variability, starting place of step length adjustment, take-off accuracy (absolute take-off error, sum of toe-to-board distances at the take-off without regard to the direction of error divided by the number of attempts), and average step velocity during five final steps.

Statistical analysis

The general linear model with repeated measures was used to test differences between approach conditions (with and without the check-mark) and maximum footfall variability (10-1 step before the take-off). When significant effects were observed, Tukey's post-hoc tests were applied. Pairwise comparison between conditions was conducted to examine the difference in the accuracy of the take-off, onset of step length adjustment and approach run velocity. An alpha level of $p < 0.05$ was used as a significance criterion in all statistical comparisons. Statistica for Windows version 10.1 PL, software was used for all calculations.

RESULTS

Figure 1 shows the footfall variability during approach run in both tested conditions. The results of the analysis revealed a significant interaction, $F_{10, 110} = 3.13$, $p < 0.01$; main effect for conditions $F_{1, 11} = 12.06$, $p < 0.01$ and main effect for steps $F_{10, 110} = 18.59$, $p < 0.001$. Post hoc analysis showed that the footfall variability was significantly ($p < 0.05$) different from 6th to 1st step from the board for both approach run conditions. Further pairwise analysis indicated that the take-off accuracy was significantly ($p < 0.05$) greater, and onset of step length adjustment was significantly ($p < 0.05$) earlier in the check-mark conditions than seen in non-check-mark conditions (Fig. 2-3). There is no differences in approach run velocity between conditions (Fig. 4).

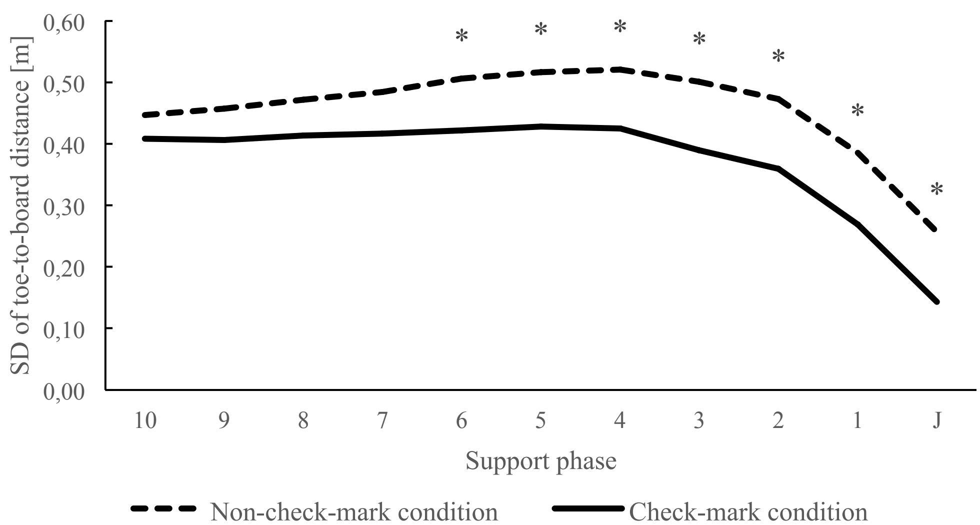

Figure 1. Footfall variability over 10 steps during the approach run in the check-mark and non-check-mark conditions.

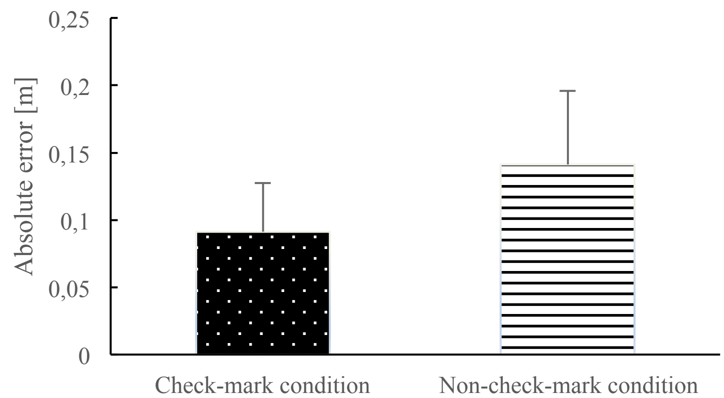

Figure 2. Mean take-off accuracy for the check-mark and non-check mark conditions. Both conditions were significantly different from each other, $p<0.05$. Error bars represent standard deviation.

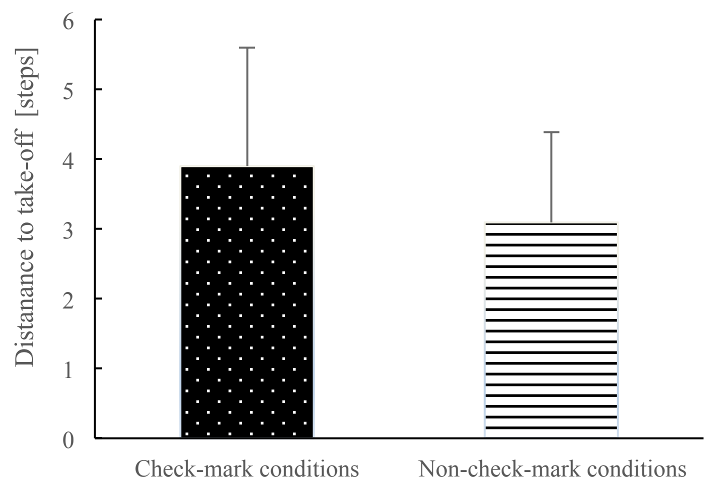

Figure 3. Mean onset of step length adjustment for the check-mark and non-check mark conditions. Both conditions were significantly different from each other, $p<0.05$. Error bars represent standard deviation.

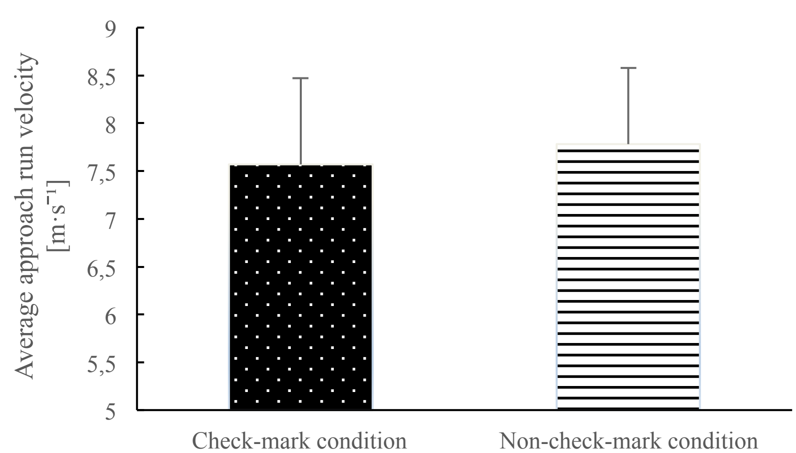

Figure 4. Mean approach run velocity for the check-mark and non-check mark conditions. Error bars represent standard deviation.

DISCUSSION

The major findings of this study are that using the coach's check-mark on the run-way may be associated with the greater take-off accuracy by a change in the step length adjustment pattern during the approach run in long jump performance. Lower of footfall variability and earlier onset of step length adjustment were found in the check-mark condition then that observed during the non-check-mark condition in novice long jumpers. The approach run velocity was not different between two conditions.

Based on the previous study (Hay, 1988; Greenwood, 2014), it was expected that implementation of the check-mark for the approach run would increase take-off accuracy in long jump. In examining possible mechanisms for this enhancement, it is logical to suggest that it may be related to more effective gait regulation. Previous researchers reported that elite long jumpers displayed less variable footfall pattern than novice or non-long jumpers, as well as at the same time the greater accuracy was shown in them. This may suggest that both theses variables are dependent on each other. The stronger evidence was brought by Makaruk et al. study (2015), where the group of top class female long and triple jumpers showed low and medium variability of footfall placement during all the phases of the approach run. They achieved the greater degree of accuracy compared to the group with high level of footfall variability. To explain this it is assumed that the high variability in footfall placement over attempts in long jump may be a result of inconsistent step regulation due to too short, too long steps or non-regular step adjustment. This situation provides two findings. Firstly, athletes need to have some relatively similar programmed step pattern during the approach run in each attempt. Secondly, the step length adjustment may be less dramatic in more experienced athletes because they produce less a cumulative effect (accumulated error of footfall placement) during the 'acceleration' phase. As we mentioned in the introduction, the visual system gather time-to-contact information (called 'tau') to make step length adjustment during the 'zeroing-in' phase, where the accumulated error is eliminated (Lee et al., 1982). Therefore, we believe that the check-mark in the middle of the run-way is the reference point for an athlete that expedites step length adjustment by more consistent gait pattern in the 'acceleration' phase and then in the 'zeroing-in' phase.

The above-mentioned conclusions find support in previous research by Greenwood (2014). However, in his study he used the board markers that placed aside for the take-off board. He observed that the board markers condition resulted in low footfall variability during approach run in comparison to the non-markers condition in horizontal jumping athletes. This finding may suggest that without regard for the placement of the marker (or the check-marker) on the run-way, it facilities to regulate the gait pattern. The other studies need to be addressed to resolve this issue in details, especially in the group of skilled athletes. We assume that the size of the marker or its visibility may play an important role here. These findings also imply important practical training solutions. The board markers are used very often during the competitions, but less often during the training. It means that they may provide different gait regulation and as a consequence different step length adjustment during competition and training. And when the board mark is not utilized during a competition, using the check-mark may bring an advantage by less footfall variability and better accuracy of the take-off.

In the current study, we demonstrated that the onset of step length adjustment appeared one step earlier with using the check-mark than seen without the check-mark. The last study (Makaruk et al., 2015) showed that the place of the onset of the step length adjustment may determine velocity within the last part of the approach run that is a key for horizontal jump results (Hay et al., 1986; Lees et al., 1994). But we did reveal differences in approach run velocity between both the check-mark and non-check-mark conditions in the present study. Probably one step distinct was too small to achieve the differences in approach speed. In addition, the skill level of subjects was different in these two studies. However, it is important to see that utilizing the check-mark reduced an influence of the spatial constraints (like the board) without a slowing down during the final steps of the approach run. It is worthy to note here that in Maraj et al. study (1998), athletes who were instructed to be accurate at the take-off showed a tendency to decrease velocity at the take-off. Therefore, we believe that using the check-mark may support tasks that require athletes to produce fast and accurate movements. Our findings are not in line with some coaches' suggestions (Magill & Anderson, 2007; Greenwood, 2014) who claim that speed decreases due to looking down or the lack of head stability during the approach run when the check-mark is used.

Finally, based on the prior suggestions (Hay, 1988; Greenwood, 2014) and the findings reported in the present study, it is recommended that low skilled athletes or athletes with inconsistent pattern of gait regulation should employ the check-mark on the run-way during their training and competitions.

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