COMPARISON OF KINEMATICS IN REPEATED 30 M SPRINTS IN FEMALE SOCCER PLAYERS

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The aim of this study was to examine the effect of sprint repetition on running kinematics (step length, frequency, contact and flight time and vertical stiffness) during a repeated sprint ability test in female soccer players. Seventeen subjects performed seven 30m sprints every 30th second in one session. Kinematics was measured with an infrared contact mat and laser gun and running times with an electronic timing device. The main findings were that sprint times increased in the repeated sprint ability (RSA) test. Furthermore, the main changes in kinematics during the RSA test were an increased contact time and decreased step frequency and vertical stiffness, while no change in step length was observed. Employing this approach in combination with laser gun and infrared mat over 30 m makes it very easy to analyse kinematics in repeated sprint ability in training. It was concluded that fatigue induced in repeated 30 m sprints in female soccer players resulted decreased step frequency and increased contact time and decrease vertical stiffness.

KEY WORDS: step length, step frequency, contact time, flight time, vertical stiffness

INTRODUCTION: In soccer, players regularly need to perform maximal sprint efforts, also called repeated sprint ability (Dawson et al., 1998). It is often trained and tested in 5-18 sprints varying between 20-40m, with recoveries of between 15-30 s (Glaister et al., 2008). This ability reduces during soccer matches due to fatigue (Nagahara et al., 2016). Therefore, repeated sprint ability (RSA) have been investigated the last 15 years, but mainly with the focus upon physiological parameters (Bishop et al., 2011; Girard, Mendez-Villanueva, et al., 2011; Spencer et al., 2005). Only a few studies have studied the biomechanical aspects of RSA (Girard et al., 2015; Morin et al., 2011). Morin et al. (2011) studied horizontal and vertical ground reaction forces for each step after a multiple-set repeated sprint series performed on a treadmill. They found that the total force production capability and the technical ability effectively against the ground were altered during repeated sprints series. Girard et al. (2015) included kinematical analyses on 5x5 seconds sprints on a treadmill. They observed that the propulsive power and step frequency decreased with fatigue, while contact time and step length increased. In both these studies the subjects had to run on an instrumented treadmill, which could influence their kinematics.
Therefore, the aim of this study was to examine the effect of sprint repetition on running kinematics during a repeated 30 m sprint ability test in female soccer players.

METHODS: Seventeen experienced female soccer players (age 17.4±0.5 years, body mass 62.3 ± 7.2 kg, body height 1.68 ± 0.05 m) performed 7x30 m sprints with a new start every 30 second. In the rest periods subjects jogged back to the start. 30 m sprints were chosen as distance since in a regular soccer match, the average duration of movements with high intensity (Spencer et al., 2005) is similar to the duration of a 30 m sprint. The test was performed in an indoor sports hall on a plastic surface (Pulastic 2000 TP, Sika Descol B.V., Deventer, the Netherlands). The 30 m times were measured with two pairs of wireless photocells (Brower Timing Systems, Draper, USA). Participants initiated each sprint from a standing start in a split stance with the lead foot behind a line taped on the floor 0.3 m from the first pair of photocells and the contact mat. Measurements were performed continuously throughout the sprint test using a laser gun (CMP3 Distance Sensor, Noptel Oy, Oulu, Finland) sampling at 2.56 KHz to measure velocity and an infra-red mat of 30 m long, sampling at 500 Hz (contact and flight time). These recordings were synchronised with the Musclelab 6000 system (Ergotest Technology AS, Langesund, Norway). This made it possible to measure contact and flight time directly with the infra-red mat, while step

frequency and step length were calculated for each step by the formulas: Step frequency = 1 / (contact time + flight time) and Step length = velocity * (contact time + flight time). Velocity for each step was derived from the laser gun. Vertical stiffness for each step during the 30 m sprints was calculated based on the formula: $k_{vert} = F_{max} / \Delta y_{contact}$ described in detail by Morin et al. (2005). Kinematics from 2nd to 13th step were averaged and used for further analyses.
To compare the sprint times and kinematics between the seven sprints a one-way ANOVA for each variable was used. Post hoc pair wise comparisons with Holm–Bonferroni correction were conducted to locate differences. The level of significance was set at $p<0.05$ and all data were expressed as mean ± SD. Statistical analysis was performed by using SPSS 23.0 for windows (SPSS, inc., Chicago, IL).

RESULTS: The 30 m times increased significantly each repetition from 2nd to 5th sprint and decreased significantly in 7th compared with 6th sprint (Fig. 1).

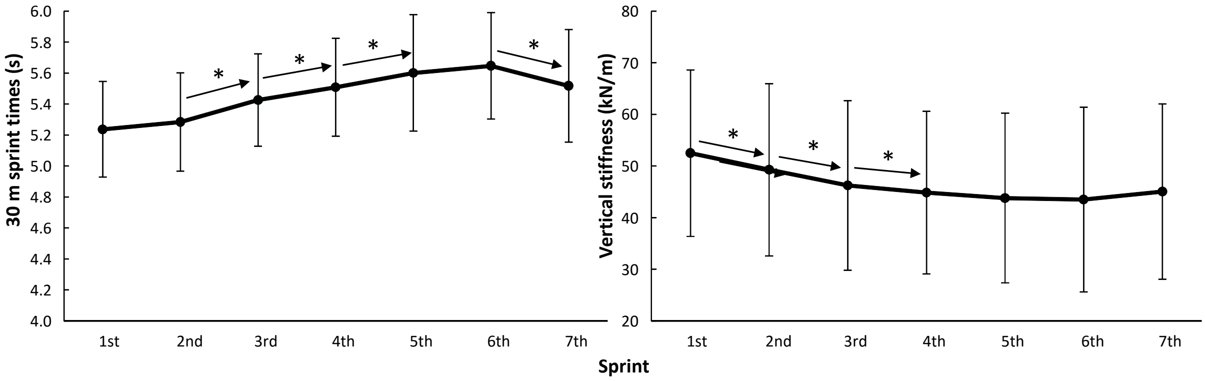

Figure 1. Average sprint time and mean vertical stiffness in each sprint (± SD).
*** indicates a significant change between adjacent sprints.**

Contact times increased significantly each repetition from 1st to 5th sprint, while flight time increased significantly each repetition in 1st to 3rd sprint (Fig. 2). This resulted in a significantly reduction in vertical stiffness each repetition in 1st to 4th sprint (Fig. 1).

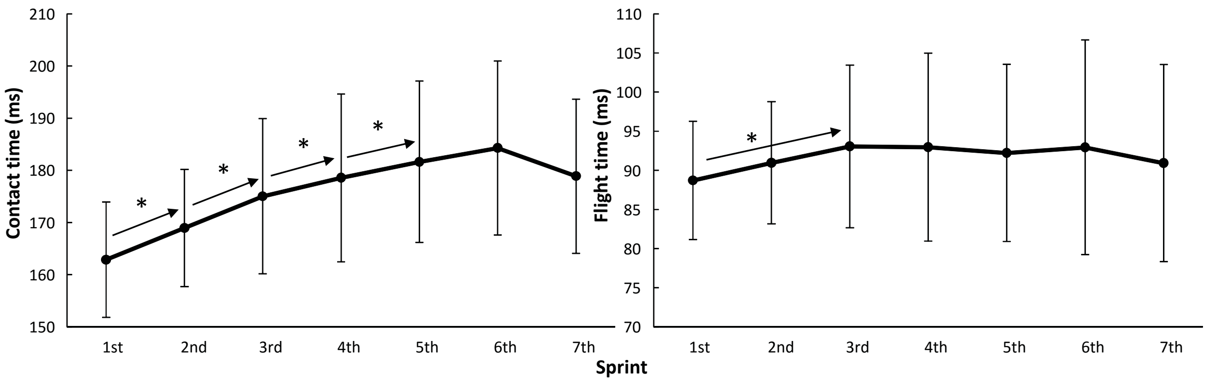

Figure 2. Average contact and flight times in each sprint (± SD).
*** indicates a significant change between adjacent sprints.**

Step frequency decreased significantly each repetition from 1st to 3rd sprint and between 3rd and 5th sprint. It increased significantly in 7th compared with 6th sprint. No significant differences were found for the step length (Fig. 3).

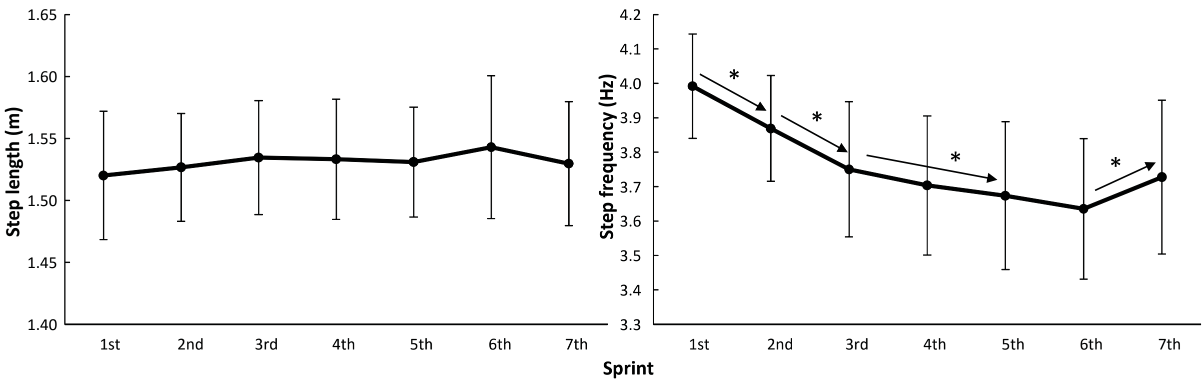

Figure 3. Average step length and step frequency in each sprint (± SD).
*** indicates a significant change between adjacent sprints.**

DISCUSSION: Sprint times increased in the RSA test with +5.7%, which were mainly caused by increased contact times (+9.6%), decreased step frequency (-6.7%) and vertical stiffness (-14.2%), while no changes in step length (+0.9%) were observed. These findings were in accordance with the study of Girard et al. (2015) on 5x5 s treadmill sprints. As fatigue developed (increased sprint times) with sprint repetition increase in contact time was related with a decrease in step frequency. This resulted on a lower vertical stiffness (Girard et al., 2015; Morin et al., 2005). No differences in step length were found in the present study, which was not in line with the study of Girard et al. (2015) who found a slight increase of step length and Morin et al. (2011) who found a decrease in step length. This discrepancy between the studies was probably caused by the way it was tested upon. In our study subjects sprinted on a track, while in the earlier studies the tests were performed on an instrumented treadmill. In the present study no kinetic measures were made, but since flight time did not change much and no differences were found in the step length, it was possible to state that propulsive power decreased, which also was observed by Girard, Micallef, et al. (2011) and Girard et al. (2015).

In the last sprint of the RSA test subjects ran faster than the one before (Fig. 1), which was probably caused by using pacing strategies (Ferraz et al., 2012; Millet, 2011). As the subjects knew how many repetitions they had to perform, they first increased sprint times due to fatigue, but used in the last sprint a so-called “end spurt.” According to Millet (2011) there is always a reserve for muscle recruitment (the security reserve) that can be used for the “end spurt” at the highest level of peripheral fatigue. This decrease in sprint time in the last sprint was mainly caused by the increase in step frequency and shorter contact time, which again indicated that these two kinematic variables were the most important variables that influenced running performance during the RSA test. A limitation in the present study was that the subjects were not so familiar with this repeated sprint test and therefore showed this pacing strategy, while earlier studies did not show this decrease in sprint time on the last sprint (Bishop et al., 2011; Girard, Mendez-Villanueva, et al., 2011).

In the present RSA test fatigue caused mainly significant changes to the kinematics of a temporal aspect like the increased contact time and lower step frequency and not in the propulsive forces as found in earlier studies (Girard, Micallef, et al., 2011; Morin et al., 2011). These different findings could be the result of the number of repeated sprints. In the present study only seven sprints were performed, while in the other studies twelve (Girard, Micallef, et al., 2011) and four sets of five 5 s (Morin et al., 2011) sprints were conducted, which could result in more fatigue and thereby also in a loss of propulsive force. Several muscular and neural factors could cause these kinematic changes as Girard, Mendez-Villanueva, et al. (2011) stated. The muscular factors like muscle excitability, energy supply and metabolite accumulation are difficult to measure in the current set up. However, the neural factors like the neural drive and muscle recruitment strategies that could limit sprint performance are possible to measure by electromyography measurements. This should be included in future studies to gain more information about what limits the RSA performance. It could help coaches, researchers and athletes with more detailed information about possible changed kinematics that occurs during repeated sprints.

CONCLUSION: Based upon the findings of the present study we concluded that fatigue induced in repeated 30 m sprints in female soccer players mainly affected kinematics by decreased step frequency and increased contact time and decrease vertical stiffness, while step length was not affected.

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