# MECHANICAL LOAD AND SOCCER SPECIFIC SPRINTS

**Wolfgang Potthast, Uwe Kersting and Gert-Peter Brüggemann**

**German Sport University Cologne, Germany**

The main purpose of this study was to identify a crucial parameter for fast short sprints with changes of movement direction. A second topic was the evaluation of whether or not, the ability of linear sprints and sprints with changes of movement direction demand the same expertise. A first league German soccer team (n=15) performed a 40m linear sprint test (LST) and a non linear sprint test (NLST), which combined short 3m-linear sprints and turns of 90° and 180°: Ground reaction forces and three dimensional kinematic data during the 180°-turn were sampled. No significant relationship was found in the comparison of the results in the LST and NLST. Between the mechanical work done during a 180°-turn in a short sprint of 6m and the running time, significant correlation were found. The mechanical work appears to be the crucial factor involved in performing a short sprint with a 180°-turn, whereas the ability of linear sprinting and non linear sprinting appear to be unrelated in soccer specific distances.

**KEY WORDS:** sprinting, direction of movement, mechanical load

**INTRODUCTION AND PURPOSE:** The maximization of performance related to human movement is of major interest in sport science. Human movements are the results of internal and external forces and moments. Therefore, an analysis of the interaction between performance enhancement and mechanical load could lead to valuable information and should be investigated. In running and sprinting for instance, the ground reaction force (GRF) increases with increasing running speed (Cavanagh & Lafortune 1980, Munro et al. 1987). In soccer, highly intensive linear sprints occur, as well as short sprints in which changes in the movement direction between 90° and 180° also take place (Gerisch, Weber & Merheim 1988). It has not yet been investigated which factors are crucial for fast sprinting which also involves changes of movement. In addition, there is a lack of clarity on whether or not fast non linear sprints demand the same abilities of the athlete as linear sprints.
The purpose of this study was twofold: first of all, it was necessary to identify a mechanical variable on which the performance of sprinting with changes of movement direction depends. Secondly, to identify whether or not linear sprints over soccer specific distances demand the same abilities as sprinting which includes changes in direction of movement.

**METHODS:** A German first league soccer team (n=15) participated in a soccer specific sprint test: To establish their linear sprinting abilities 40m-sprints (LST) were performed with intermediate times at 10m, 20m and 30m. A non linear sprint test (NLST) over 24m with the addition of changes in movement direction of 180° and 90° yielded the sprinting abilities of athletes, including changes in movement direction (Figure1). To determine the running performance, the total running time was measured as well as the intermediate time after a 6m run including a 180° turn (Figure 1). Ground reaction forces (GRF) of both feet were measured separately at the 180° turn using two piezoelectric force plates. Three-dimensional data of the 180°-turn were obtained by digitizing the videotapes of two 120Hz cameras. The total mechanical energy (W) expended during the 180°-turn was calculated by the sum of the absorbed energy ($W_{abs}$) and the energy used ($W_{off}$) for push off (Figure 2). The following mechanical data were established and statistically analyzed by a correlation analysis:

- 10m, 20m, 30m and 40m running time in the LST
- total running time and intermediate time in NLST
- peak GRF of both feet at 180°-turn
- mechanical work (W) done during the 180°-turn
- mechanical power (P) during the 180°-turn

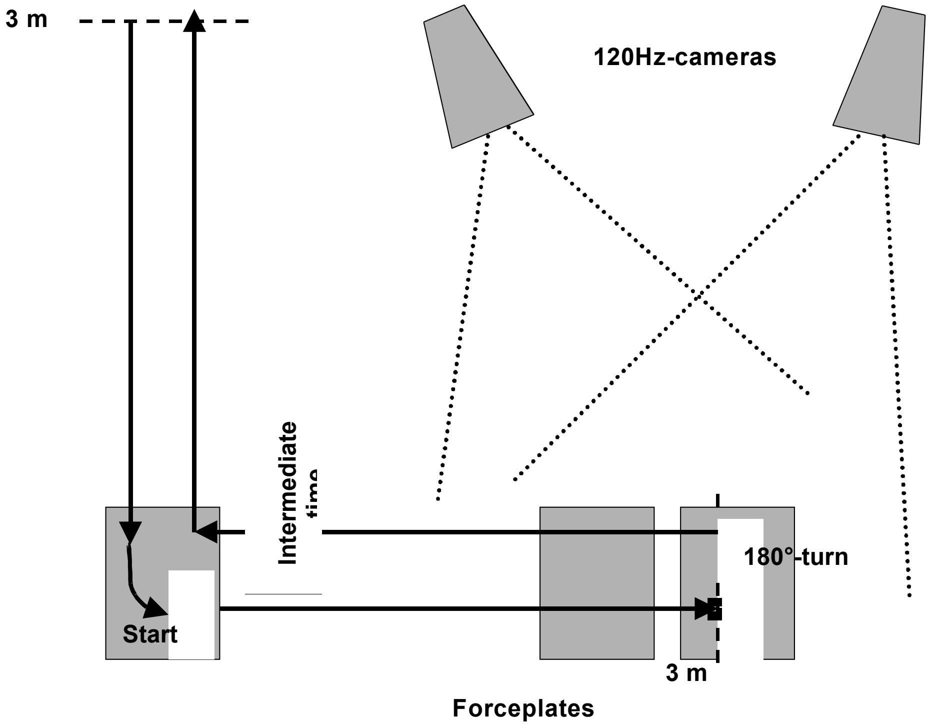


**Figure 1 - The non linear sprint test (NSLT).**

**RESULTS AND DISCUSSION:** The results are shown as mean values in table 1.

**Table 1 Mean Values and Standard Deviation**

| | Linear sprint test | | | | Non linear sprint test | | | |
|---|---|---|---|---|---|---|---|---|
| Para-meter | 10m time | 20m time | 30m time | 40m time | Total time | Intermedi-ate time | GRF 180°-turn | W 180°-turn |
| Mean values | 1.70±0.05 s | 2.96±0.09 s | 4.14±0.10 s | 5.31±0.12 s | 7.55±0.45 s | 1.66±0.08 s | 2.5 BW | 8.5±0.9 J/kg |

The correlation analysis showed a highly significant correlation between the running times of the different distances in the LST (r=0.791** - 0.976**; p<0.01). No remarkable differences were identified between the linear sprinting abilities from 10m to 40m. However, the linear sprinting abilities from 10m to 40m appear to be related. No correlation was found between the results of the LST and the NLST (r=0.143 – 0.327). A difference between the ability of linear sprinting and sprinting with changes in movement direction of 90° and 180° was also identified.

In order to identify a parameter on which the performance of non linear sprints depends, ground reaction forces and the mechanical work of the 180°-turn were compared both to the total running time and to the intermediate running time of NLST. No relationship was found between the running times and the peak GRF. Significant correlation between the mechanical work done during the 180°-turn and the intermediate running time was found (r=-0.75*, p<0.05). The correlation between P and the intermediate running time showed the same correlation coefficient.

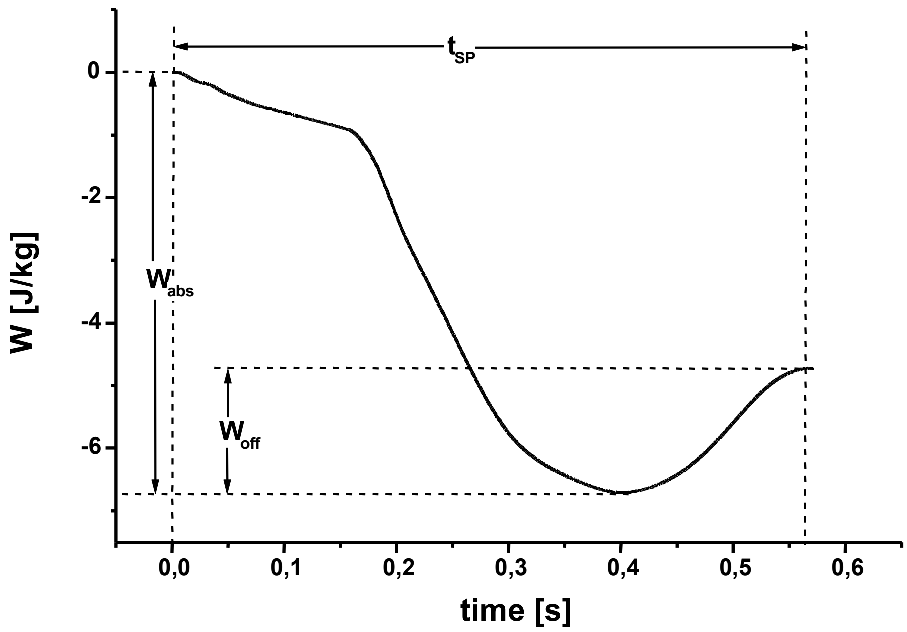


**Figure 2 - Typical work-time-history during the 180°-turn with the parameters $W_{abs}$, $W_{off}$ and $t_{SP}$.**

**CONCLUSIONS:** Linear sprinting abilities and non-linear sprinting abilities in soccer specific distances are dependent on different parameters. Therefore it can be maintained, that it is not sufficient to determine merely the running time of linear sprints for an assessment of speed in soccer.

Concerning the ability of sprinting with changes of movement direction, a parameter could be identified, which appears to be relevant for the performance, namely the mechanical work during the 180° turn. To perform a short sprint with a 180° turn, the athlete has to achieve a high level of kinetic energy before braking for the turn and also a high level of kinetic energy right after the turn. Therefore it is necessary to do a considerable amount of mechanical work during the 180° turn.

It has not yet been established on which joints and in which time history, the transition of the energy occurs. Future studies in this area could provide valuable information for training and diagnosis . Additional information on this topic could also be helpful for the development of a variety of sports equipment, especially for the design of athletic shoes.

**REFERENCES:**


Cavanagh, & Lafortune (1980). Ground reaction forces in distance running. *Journal of Biomechanics, **13**(1), 397-406.*

Gerisch, Weber, & Merheim (1988). Leistungsdiagnostische Aspekte zur Trainingssteuerung im Fussball. *Sportspiele: Animieren – Trainieren.*

Munro, C.F., Miller, D.I., & Fuglevand, A.J. (1987). Ground reaction forces in running: a reexamination. *Journal of Biomechanics,* **20**(2), 147-155.

*Acknowledgments*
This study was supported by NIKE.