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**ORIGINAL ARTICLE**

# EFFECT OF THE USE OF LOFSTRAND CRUTCHES AND PROSTHESES ON SOME GAIT PARAMETERS IN AMPUTEE FOOTBALL PLAYERS

***Abstract***

Lofstrand crutches are used in the pre-prosthetic period after amputations as well as in combination with prostheses in geriatric amputees. Amputee football is gaining popularity in countries with increasing numbers of terrorist incidents and traffic accidents. The majority of athletes playing amputee football, played with two Lofstrand crutches and without prostheses, use prostheses in their daily lives. In this study, athletes who use prostheses in their daily lives were asked to walk with their own prostheses and without, with the crutches they use while playing football, and the two gait patterns were compared with regards to some gait parameters (stride length, stride time, speed, distance and cadence). The study included five registered amputee football players with a unilateral lower extremity amputation (above-knee amputees, AKAs/knee disarticulation, KD). The subjects were asked to walk at a comfortable pace on a 25 meter track using prostheses and Lofstrand crutches. Data were collected through the F-Grip system (Tekscan Inc, Boston, USA) from their Loftstrand crutches and through the F-Scan Mobile system from their footwear (Tekscan Inc, Boston, USA). A comparison of the two gait patterns revealed that there is a difference in stride length, speed, distance and cadence though statistically insignificant (p=.068). However, the difference observed in the stride time was statistically significant (p=.043). As a result of their familiarity with Lofstrand crutches used in trainings and games and their sports skills, amputee footballers displayed a superior gait pattern with crutches compared to their prosthetic gait.

**Key Words:** Crutch, prosthesis, gait analysis, amputee, football

## INTRODUCTION

Lofstrand crutches are used in the pre-prosthetic period after amputations as well as in combination with prostheses in geriatric amputees. Although the prosthetic gait of amputees who do not use Lofstrand crutches changes depending on the level of amputation, the functionality of the prostheses and some other mechanical factors, it is observed that their gait is usually reciprocal. Amputees who use either Lofstrand crutches or prostheses are also expected to display different gait patterns depending on their personal habits (Youndas et al., 2005).

The loss of a limb as a result of amputation also causes the center of balance to shift. In that case, the amputee will develop a suitable gait pattern in order to maintain his balance/adapt to the shift of the center of balance. It is observed that amputees who do not use prostheses usually have a swing-through gait (STG) when they walk with Lofstrand crutches. When Lofstrand crutches are used, the STG is expected to be faster than the reciprocal gait (RG) with Lofstrand crutches. Moreover, one would expect that the STG with Lofstrand crutches of amputees who do not use prostheses would have a different pattern than that of the other groups (amputees with prostheses, spinal cord injuries, spina bifida, etc.).

Major factors that distort the gait pattern in amputees with prostheses is that they lose the advantage of using their ankle while walking, and that, in above-knee amputees (AKA)/knee disarticulation (KD) and higher levels of amputation, they try to substitute active knee functions with the prosthetic equipment. The loss of muscles and joints in amputees is accompanied by sensory loss. Their control over propulsion and balance needed to walk is constrained (Vrieling et al., 2008 A; Vrieling et al., 2008 B) and their gait parameters have changed. In order to produce the propulsive force, it is observed that the amputee shifts more load onto the non-affected limb (Vrieling et al., 2008 A), and the double stance time increases (Tokuno et al., 2003). This extent of this difference from a normal gait can vary depending on the level of amputation (Vrieling et al., 2008 B), and might become manifest in an asymmetrical gait (Bateni and Olney, 2002; Jaegers et al., 1995; Mates et al., 2000).

In Bateni and Olney (2002), the prosthetic and non-affected limbs were comparable with regards stride length, stride time and speed in Below-Knee Amputees (BKAs). However, the stance percentage of the non-affected limb was found to be larger than that of healthy subjects although the difference was statistically insignificant.

Amputee football is gaining popularity in countries with increasing numbers of terrorist incidents and traffic accidents. The majority of athletes playing amputee football, played with two Lofstrand crutches and without prostheses, use prostheses in their daily lives.

In this study, athletes who use prostheses in their daily lives were asked to walk with their own prostheses and without, with the crutches they use while playing football, and the two gait patterns were compared with regards to some gait parameters.

## MATERIALS AND METHOD

The study included five registered amputee football players (Table 1) with a unilateral lower extremity amputation. The subjects were asked to wear gloves instrumented with F-Grip (Tekscan Inc, Boston, USA) sensors (50 Hz). F-Scan Mobile (Tekscan Inc, Boston, USA) system sensors (50 Hz) were placed into their shoes (prosthetic and non-affected sides). A video was recorded with a 30 fps camera (Sony, TRV900E) to control synchronization. The subjects were asked to walk at a comfortable pace on a 25 meter track using prostheses and their own Lofstrand crutches they used during sports, and were allowed to practice before measurement. The subjects removed their prostheses before using their Lofstrand crutches. The 10 meter stretch in the middle of the track was taken into account in the calculation. Gait data for the Lofstrand crutches were obtained through the F-Grip sensors adhered to the gloves of the subjects, and those for the prostheses and the non-affected limb were obtained through the F-Scan Mobile sensors in the footwear.

**Table 1:** Demographic features of the subjects

| **Parameters (N= 5)** | **Mean ± SD** |
|---|---|
| Age (years) | 23.6±7.8 |
| Height (cm) | 172.5±7.1 |
| Weight (kg) | 69.5±17.3 |
| BMI (kg/m2) | 23.29±5.2 |
| Lofstrand Crutch Hand Height (cm) | 85.00±4.6 |
| Amputation Years (month) | 16.8±10.7 |
| Amputation Side | 1 left, 4 right |
| Amputation Levels | 3 Above-Knee |
| | 1 Femoral Agenesis |
| | 1 Knee Disarticulation |

## RESULTS

The gait parameters as measured with the prostheses of the athletes and with Lofstrand crutches are given in Table 2.

**Table 2:** Gait parameter values for prostheses and Lofstrand Crutches

| | Lofstrand crutches | Prosthesis | P value |
|---|---|---|---|
| Stride Length (cm) | 84.20±6.21 | 72.71±5.33 | 0.068 |
| Stride time (sec) | 1.222±0.079 | 1.290±0.075 | 0.043 |
| Speed (m/sec) | 1.38±0.17 | 1.12±0.10 | 0.068 |
| Distance (m/min) | 82.86±10.13 | 67.30±6.01 | 0.068 |
| Cadence (step/min) | 98.21±6.18 | 92.63±6.09 | 0.068 |
| Non-affected limb stance phase (%) | 63.59±2.43 | 65.25±2.78 | |
| Non-affected limb swing phase (%) | 36.41±2.43 | 34.75±2.78 | |
| Stance (prosthesis or Lofstrand crutches) | 58.03±6.43 | 50.45±4.41 | |
| Swing (prosthesis or Lofstrand crutches) | 41.97±6.43 | 49.55±4.41 | |

A comparison of the two gait patterns revealed that there is a difference in stride length, speed, distance and cadence though statistically insignificant (p=.068), however, the difference observed in stride times was statistically significant (p=.043).

## DISCUSSION

Prostheses are the assistive device of choice for users because Lofstrand crutches place an extra load on upper extremity joints they are not used to carry and prostheses leave the hands free. Upper extremities and the trunk play a critical role in the propulsion of the body in Lofstrand crutch-assisted ambulation (Miller, 2003). Lofstrand crutch-assisted ambulation requires a lot of upper extremity strength. In a study carried out with ten healthy adults, Youdas et al. (2005) reported a general decline in gait parameters such as stride length, speed, cadence, step width and step length when subjects used Lofstrand crutches compared to when they were not (Youdas et al., 2005).

Compared to general gait values of healthy subjects (Kirtley, 2006), the ambulation data for Lofstrand crutches in this study are close to normal values regarding speed, above the upper limit for normal gait regarding stride length and much lower than normal gait values regarding cadence. The prosthetic gait of the subjects in this study, on the other hand, displayed lower values for speed and cadence compared to those in normal gait (Kirtley, 2006), but remained within the normal range for stride length.

Although statistically insignificant, this study revealed higher values in favor of Lofstrand crutches for stride length, speed and cadence in comparison with the prosthetic gait of the same subjects. The authors also observed that, vis-a-vis stride time, the prosthetic gait was slower in a statistically significant way. In his study where he asked non-amputee subjects (spinal cord injuries, cerebral palsy, osteogenesis imperfecta) to walk with Lofstrand crutches, Bhagchandani (2009) reported a wide range for cadence (78.29-103.37 step/min), speed (0.53-0.62 m/sec), step length (0.64-0.95) and stance ratios (56.31-68.55%). In our study, all values, except those for speed, were within the value ranges obtained in Bhagchandani's study (2009). As a result of amputation, weight will be lost together with the loss of an extremity. Therefore, a change in gait parameters is expected when Lofstrand crutches are used for ambulation. The difference between the above-mentioned speed values could be attributed to the fact that the subjects in Bhagchandani's study were non-amputees, whereas ours were amputee athletes.

Royer and Wasilewski (2006) reported a cadence value of 107.2 step/min in BKAs. The fact that we included subjects with higher levels of amputation (AKAs/KD) in our study might be the cause of the difference. Jaegers et al. (1995) noted values comparable to ours in their own study for speed, stride length, stride time and cadence.

The stance/swing ratio is expected to be 60/40 in the gait of healthy subjects (Kirtley, 2006). Slavens et al. (2009) reported a stance/swing ratio of 50/50 in STG for non-amputee cases using Lofstrand crutches. In their study with healthy subjects, Bhagchandani et al. (2009) reported a ratio of 55/45 for this parameter. In the STG of our amputee subjects with Lofstrand crutches the stance/swing ratio was observed to be 63.5/36.5 for the non-affected limb and 58/42 for the Lofstrand crutch replacing the amputated extremity. This difference indicates that the STG-style gait values of our athlete subjects walking with Lofstrand crutches are still close to normal ranges.

In their study, Bateni and Olney (2002) reported a stance/swing ratio of 58.6/41.4 with healthy subjects. They also reported a stance/swing ratio of 64.4/35.6 for the non-affected limb of amputees with prostheses, and a ratio of 60.2/39.8 for the affected limb. In our study, these ratios during the use of prostheses were 65.25/34.75 and 50.45/49.55 for the non-affected and affected limbs respectively. We believe that the difference between the outcomes of the two studies is because Bateni and Olney's (2002) subjects were BKAs, whereas ours were AKA/KD cases and therefore were using a mechanical knee joint. The use of a mechanical knee joint results in the loss of confidence in placing load onto the prosthetic limb (Hafner et al., 2007).

In their study, Jaegers et al. (1995) reported stance/swing ratios of 63.4/36.6 and 58.4/41.6 for the non-affected limb and the prosthetic limb respectively for AKAs. Values obtained from the prosthetic gait of our subjects for the stance/swing ratios on the non-affected side are close to those in Jaegers et al.'s (1995) study, however, compared to their study, the stance phase is shorter in our subjects on the prosthetic side. We believe that this difference between our cases with similar amputation levels could be attributed to physical differences between subjects as well as technical differences such as the socket fit, suspension type and the prosthetic knee joint/foot.

## CONCLUSION

Compared to Lofstrand crutches, prostheses are disadvantageous in several gait parameters measured in the study. The decrease in the stance time when using prostheses results in the subject displaying an asymmetrical gait. Although the subject uses his upper extremities with small muscle groups for Lofstrand crutch-assisted ambulation, the gait is still more symmetrical compared to the prosthetic gait. As a result of their confidence in using Lofstrand crutches they have developed during trainings and games, and their acquired sports skills, amputee footballers displayed a more symmetrical gait pattern compared to the prosthetic gait.

### Limitations

The main limitation of this study is the low number of subjects who have a similar level of amputation, play football and are willing to participate in the study. The fact that there are very few, if any, studies that examine gait parameters of amputees who use Lofstrand crutches rather than prostheses limits the possibilities for comparison. This study did not aim to compare gait data of the non-affected and affected sides.

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