Influence of Amputation on Match Performance in Amputee Soccer

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Objective: The aim of this study was to investigate the influence of amputation on match performance in amputee soccer by comparing amputee and non-disabled soccer players.

Methods: We recruited 12 Japanese amputee soccer players and 12 Japanese non-disabled university soccer players in this study. Match performance data were collected across five matches. Total distance and high-intensity running (HIR: $\geq 13 \text{ km} \cdot \text{h}^{-1}$) were collected using global positioning systems technology. Heart rate (HR) was recorded using short-range radio telemetry. In addition, ratings of perceived exertion (RPE) were assessed immediately after the first and second halves of match play using the Borg RPE scale.

Results: The HR response and RPE were significantly different between the amputation group and non-disabled group ($p < 0.01$). The mean HR, mean $\%HR_{\text{max}}$, and RPE were $176.8 \pm 7.9 \text{ beats} \cdot \text{min}^{-1}$, $96.3 \pm 4.6\%$, and 15.8 ± 1.3 , respectively, in the amputation group and $144.4 \pm 15.6 \text{ beats} \cdot \text{min}^{-1}$, $72.2 \pm 7.8\%$, and 13.4 ± 2.0 , respectively, in the non-disabled group.

Conclusion: Results of this study indicate that HR response and RPE are affected by amputation. These findings would indicate that the energy cost of physical activities is higher in the amputation group than in the non-disabled group.

Key words: match-play, amputee football, inclusive sport

Introduction

Amputee soccer is uniquely designed for the physically challenged, those who have undergone amputations, as well as those with extremity dysfunctions. Amputee soccer players are classified into two groups: 1) outfield players, who have had unilateral lower limb amputation, foot amputation, or locomotor disabilities (i.e., underdeveloped limbs) and, 2) goalkeepers, who have had a unilateral upper-limb or hand amputation¹⁾. Amputee soccer

can be played on natural or synthetic grass with minimum field size of $60 \times 30 \text{ m}$ and maximum size of $70 \times 55 \text{ m}$. A match consists of competitive play from two teams, each consisting of no more than seven players, one of whom is the goalkeeper. The duration of a match is two periods of 25 minutes, with a half time interval that does not exceed 10 minutes. All outfield players play on one leg using bilateral crutches without wearing an artificial leg during the match. It is prohibited to control the ball using the crutch during the game²⁾.

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Don Bennett began modern amputee soccer in Seattle, United States, in 1980. In the game's inception, amputee soccer was used as a form of training that helped skiers with disabilities from the USA National Team maintain proper endurance and fitness levels during the summer³⁾. Amputee soccer, as a variation of one of the best-known sports in the world, quickly became popular as there were no age limits and no gender restriction to match play. Until 1987, the game was played on soccer pitches with standard dimensions and with 11 players on each team. In 1998, the first official Amputee Football World Cup tournament was held in England. In the same year, the International Amputee Football Federation (IAFF) was founded in Moscow. Eventually, the IAFF was transformed into the World Amputee Football Federation (WAFF) and the Amputee Football Federation of Africa (AFFA). WAFF standardized the rules of the match, and as a result, amputee soccer has gained popularity in the disability community all over the world, with continually increasing numbers of athletes.

Amputee soccer is also gaining popularity in Japan. The Japanese amputee soccer league includes nine amateur clubs. The Copa amputee in Japan and Japan Amputee Football championships are held annually in Japan, and the number of competitors is increasing. Additionally, the Japanese amputee soccer national team demonstrating remarkable competitive improvement. In the Amp Futbol Cup in 2017, Japanese national team was ranked third and Japanese player was award the best player. Recently, non-disabled individuals are also participating in amputee soccer as an inclusive sports competition. Several studies have examined the physical characteristics of amputee soccer players⁴⁾⁻⁶⁾, however, there have been limited reports on the impact of amputation on amputee

soccer performance. Therefore, the aim of this study was to investigate the influence of amputation on match performance in amputee soccer by comparing amputee and non-disabled soccer players.

Materials and Methods

1. Subjects

We recruited 12 Japanese amputee soccer players in the amputation group and 12 Japanese university soccer players in the non-disabled group. The physical characteristics of both groups are presented in Table-1. All participants were aware of the study methods, procedures, and risks, and signed an informed consent document before participating in the study. This study was conducted according to the Declaration of Helsinki and was approved by the Ethics Committee for Human Experiments of Juntendo University.

2. Experimental design

Match performance data were collected across five matches. The final dataset comprised of 32 samples for which data were available at all time points during the matches. The matches lasted two equal periods of 25 minutes, plus any additional time. The half time interval was 10 minutes. Subjects used their own set of crutches during the match. Matches were played on an artificial turf pitch measuring 60 m × 40 m (length × width) that conformed to the official WAFF rules (i.e., International 7 vs. 7 Rules). Goals of 2.2 m × 5 m × 1 m (height × width × depth) and official balls were used during the matches.

3. Data collection and analyses

Match performance data measured as running distance and speed category were collected using

Table-1 Physical characteristics and amputee soccer experience

	Amputation group (n=12)	Non-disabled group (n=12)
Age (years)	37.0 ± 6.4**	20.0 ± 0.0
Height (cm)	173.9 ± 5.7	175.3 ± 4.2
Body mass (kg)	65.7 ± 6.3	69.2 ± 3.8
Body mass index (BMI)	24.2 ± 4.1	26.1 ± 3.0
Amputee soccer experience (years)	7.0 ± 4.9**	2.0 ± 0.2

Data are expressed as the mean ± SD. **p < 0.01 group differences.

15 Hz GPS technology (Sports performance indicator, SPI-Pro X2; GPSports Systems Pty. Ltd., Canberra, Australia) across five matches (one match dataset per player). The GPS was placed on the player's upper back inside a pocket sewn into their undershirt prior to warm-up. The GPS device was checked during the last minute of warm-up to ensure it was functioning properly. The recorded data were exported (Team AMS software; GPSports Systems Pty. Ltd., Canberra, Australia) for motion analysis after each match.

Player movement speeds were calculated based on previous studies⁷⁾ and were classified into the following categories: standing ($<0.4 \text{ km} \cdot \text{h}^{-1}$), walking ($0.4\text{--}5.0 \text{ km} \cdot \text{h}^{-1}$), low-speed running ($5.0\text{--}8.0 \text{ km} \cdot \text{h}^{-1}$), moderate-speed running ($8.0\text{--}13.0 \text{ km} \cdot \text{h}^{-1}$), high-speed running ($13.0\text{--}18.0 \text{ km} \cdot \text{h}^{-1}$), and sprinting ($\geq 18.0 \text{ km} \cdot \text{h}^{-1}$). High-intensity running (HIR) was defined as a movement speed greater than $13.0 \text{ km} \cdot \text{h}^{-1}$. The frequency and duration of each of the speed categories were recorded and calculated at both the first half and the second half of the match. The distance covered for each of the speed categories was recorded, which were summed to determine the total distance covered during a match.

The HR response was recorded using short-range radio telemetry (polar T34; Polar Electro, Kempele, Finland). Each player's HR maximum (HR_{max}) was estimated using an age-

predicted formula: $220 - \text{age}$ ⁸⁾. In addition, a rating of perceived exertion (RPE) was assessed immediately after a match using Borg's original (i.e., 6–20) scale⁹⁾.

4. Statistical analysis

Data are presented as the mean $\pm$ standard deviation. All calculations were performed using the Statistical Package for Social Sciences PC software ver. 17.0 (SPSS Inc., Chicago, IL, USA). Differences in measured variables between the amputation group and the non-disabled group were assessed using Student's unpaired t-tests. Statistical significance was inferred at $p < 0.05$.

Results

1. Match performance

The total distance covered (amputation group: $2,984.2 \pm 561.6 \text{ m}$; non-disabled group: $2,915.1 \pm 881.3 \text{ m}$) and HIR (amputation group: $205.3 \pm 100.5 \text{ m}$; non-disabled group: $224.2 \pm 176.4 \text{ m}$) over the entire match were not significantly different between the groups. Few significant differences were observed in movement speed categories between the groups (Figure-1, 2). Movement time and distance covered during walking activities were higher in the amputation group than the non-disabled group ($p < 0.01$) (Figure-1, 2).

Figure-1

Movement time during different speed categories in the amputation group ($n = 12$; dark bars) and the non-disabled group ($n = 12$; light bars). ** $p < 0.01$ group differences.

Figure-2

Distance covered during different speed categories in the amputation group (n=12; dark bars) and the non-disabled group (n=12; light bars). **p<0.01 group differences.

2. HR response and RPE

The HR response and RPE scores were significantly different between the amputation group and the non-disabled group ($p < 0.01$). The mean HR, mean %HR_{max}, and RPE were 176.8 ± 7.9 beats·min⁻¹, 96.3 ± 4.6 %, and 15.8 ± 1.3 , respectively, in the amputation group and 144.4 ± 15.6 beats·min⁻¹, 72.2 ± 7.8 %, and 13.4 ± 2.0 , respectively, in the non-disabled group.

Discussion

The purpose of this study was to investigate the influence of amputation on match performance in amputee soccer by comparing amputee and non-disabled soccer players. Results of this study showed that the total distance covered and HIR were $2,984.2 \pm 561.6$ and 205.3 ± 100.5 m in the amputation group and $2,915.1 \pm 881.3$ and 224.2 ± 176.4 m in the non-disabled group, respectively. In addition, the mean HR, mean %HR_{max}, and RPE were 176.8 ± 7.9 beats·min⁻¹, 96.3 ± 4.6 %, and 15.8 ± 1.3 , respectively, in the amputation group and 144.4 ± 15.6 beats·min⁻¹, 72.2 ± 7.8 %, and 13.4 ± 2.0 , respectively, in the non-disabled group. Comparison of physiological outcomes during amputee soccer match play indicated that the match HR response and post-match RPE are affected by amputations.

The amputation group had both higher HR responses and higher post-match RPE than non-disabled players despite the same movement time and distance covered during the match. Mengelkoch *et al.*¹⁰⁾ demonstrated that the energy cost and performance of below-knee amputees was disadvantageous during walking and running activities compared to non-amputee runners. Furthermore, it is known that the energy cost of physical activities is higher in above-knee amputees compared with below-knee amputees¹¹⁾. From these factors, it can be assumed that the energy cost of physical activities is higher in the amputation group compared with the non-disabled group. Future studies with larger sample sizes will be able to further elucidate the energy cost of amputee soccer in amputee players.

Limitations of this study should be noted. There were significant differences in some items in the physical characteristics between the groups. The match performance may also have the influence of physical characteristics. Unfortunately, we did not have the relevant data, so further investigations are needed in these points.

There have been many variations of soccer for people with disabilities. Football 5-a-side has already been introduced in the Paralympic program as a sport where visually impaired individuals (outfield players) compete alongside non-visually

impaired individuals (goalkeepers). WAFF has submitted an application to introduce amputee soccer to the athletic program of the 2020 Paralympic Games in Tokyo. In order to introduce amputee soccer to the Paralympic Games, it will be necessary to organize disability classes for standardization in competition. As with the established Football 5-a-side rules, disabled people and non-disabled people will compete together to further improve the success of amputee soccer, establishing a pioneering model of inclusive sport.

Conclusions

This study was the first attempt to investigate the influence of amputation on match performance in amputee soccer. Results from this study suggested that the HR response and post-match RPE are affected by amputations. These findings suggest that the energy cost of physical activities is higher in the amputation group than in the non-disabled group.

Conflict of interests

The authors declare that there are no conflicts of interest.

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