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Review article

RELATION BETWEEN UPPER LIMBS STRENGTH AND RUNNING SPEED IN AMPUTEE FOOTBALL PLAYERS: REVIEW

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Abstract

Amputee football is gaining popularity worldwide among individuals with disabilities. It has differences compared to normal football, such as, number of players in the field, smaller field dimensions and the usage of crutches while running. Despite the differences with normal football, amputee football requires high levels of flexibility, endurance, power, speed, and agility. Running with crutches is divided into 4 stages and within these 4 stages, an amputee player uses crutches 33% of the time, while 67% of the time uses their foot. Hereby, this study aims to show the relationship between strengthening the upper body to increase the speed of running with crutches during the game of amputee football.
A rigorous literature research was conducted based on training and sports performance. The considered databases were PubMed, Research Gate and MEDLINE, where the keywords used were "amputation" "football" "strength" "speed" "crutches". The criteria of the selected studies were the relevance of the article on the selected topic and the time of publication.
Studies conducted in this topic conclude that there is a great relation between upper strength and activities performed on amputee football match, such as running. Studies state the usage of latissimus dorsi muscle and shoulder extension movement.
This study will be useful to give a clear sighting of the importance of upper limbs training in amputee football players to increase their running speed with crutches.

Keywords: Amputation, Football, Strength, Speed, Upper limbs

1. Introduction

Amputation is defined as the absence of a limb or part of the body; usually the lower or upper limb or both. Amputation of a limb can cause some problems as compensatory movements, change of the center of gravity, decrease ability for walking, jogging, or running, higher energy expenditure, elevated heart rate and lower oxygen consumption. Regular physical activity and/or participation in sports reduces the risk of lifestyle-related diseases, which are prevalent among individuals with disabilities, and has positive effects in improving balance, muscle strength, physical fitness, and overall quality of life1. Studies have shown that sports or physical activity have positive effects on health in individuals with physical disabilities as in healthy individuals. For this reason, sports activities are often recommended for people with disabilities[3].
Amputee soccer is gaining popularity worldwide among individuals with disabilities1Activities that were initially created for recreational purposes for the disabled turned into professional branches in time. One of these sports branches created by this passion is amputee football. Amputee football, also called amputee soccer, is one of the disabled sports branches that is constantly increasing its popularity although it is not a Paralympic branch.3 In amputee soccer, outfield players have unilateral amputations of lower extremities (above the ankle) and move on the pitch with the use of elbow crutches and kick the ball only with their remaining foot. Goalkeepers, however, have a unilaterally amputated upper extremity (above the wrist) and are not permitted to leave the penalty area[2]. Amputee football is played with two teams of seven players (one goalkeeper, six players) in two periods of 25 minutes each. The pitch dimensions are 40×60 meters in amputee football. 5

Although game rules and pitch dimensions differ from normal football, it is necessary to have a high level of endurance, strength, flexibility, coordination, balance, and spinal stabilization in amputee football.
Amputee footballers use crutches, which are considered extensions of the upper limbs, to perform functional activities on the pitch and maintain balance when kicking the ball. Crutches are adjustable and bilaterally held. 5One of the main functions performed in football is running. The normalized cycle of single-leg crutch running was defined as the time from the first crutch contact to the subsequent point of crutch contact and subdivided into the following 4 phases: [1]

1- crutch stance
2- first stance
3- jumping
4- second stance

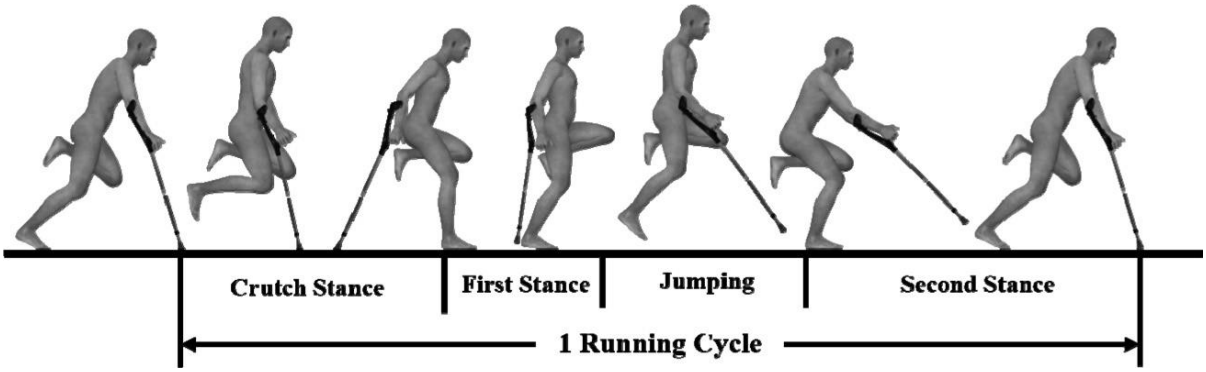

Fig 1. Single leg running with lofstrand crutches. [1]

Following this cycle, we observe that the usage of crutches while running takes 33% of the time, while usage of the lower limb takes 67% of the time of running. Naturally, lower limb strength training in amputee football players would affect directly in running speed and player overall performance. In scientific literature, in regular football players, studies have revealed a significant relationship between lower limbs strength and performance. Similarly, this idea of a relationship between lower extremity strength and performance in amputee football would be a natural outcome [7].
However, using both upper limbs for support while performing football activities, like walking and running, mean they have a direct impact on running speed. While analyzing the force distribution on the upper limbs, studies have showed that the palm holds 44.4% of the body weight at peak force throughout the gait cycle. This was performed by placing force transducers in the crutch tip and in each arm of the crutch near the armpit rest [8]. Another study shows different upper limb muscles movements, while performing different intensity tests, like 10 m Sprint and Shuttle run test [7].
Many studies have been conducted upon this idea, using different tests and methods, however there is not a direct answer for the specific question. Hereby, this literature review study aims to show the relationship between strengthening the upper body to increase the speed of running with crutches during the game of amputee football.

2. Methodology

*2.1. Research Strategy:*A rigorous literature review was performed based on training and sports performance. The considered databases were PubMed, Research Gate and MEDLINE, where the keywords used were “amputation”, “football”, “strength”, “speed” and “crutches”. Important keywords mentioned within the articles were “lower limb”, “upper limbs” and “performance.” The time span of articles chosen for this

literature review is from year 2005 to 2021. Reference lists of all selected papers were manually searched for other potentially eligible papers.

2.2. Literature Selection: The accepted scientific articles for this study were one full text. Selection of articles was conducted based on title and abstract. Acceptance criteria of the articles was done based on time of publish and the article relationship to the main topic, such as: 1) amputee football performance, 2) biomechanics of running with crutches, 3) relationship of upper extremity to lower extremity.

2.3. Data Extraction: The data relating to participant's characteristics and tests were extracted. The data extraction included sex, age, height, weight and amputation level, sprint test, shuttle run test, CMJ, one leg hops tests. (See Table 1) Each data is collected and sorted accordingly in Table 1. For ease of comparison, different units were converted to the same units as most other studies, i.e., height is reported in centimetres (cm), body mass in kilograms (kg), distance covered in metres (m)and running speed in m·s−1.

3. Results

3.1. Identification and selection of studies: Through the original database search 27 articles were identified. Following the removal of duplicates and screening for eligibility, 5 articles remained for analysis. The studies selected for analysis date between years 2015 to 2021[2], [5], [7], [9], [10].

3.2. Study Characteristics: Table 1 shows the demographic characteristics of the 5 studies included in the review. The demographic data of the 5 studies included number of participants (n=5), exclusion of subjects (n=4), where one study reported the number of excluded subjects directly (n=1) [7], sex (n=5), age (n=5), weight (n=5), height (n=5). All the studies included amputee football players and excluded goalkeepers, which signifies the lower amputation of subjects, where two studies reported the amputation level of the subjects directly(n=2) [2][5].
Table 2 shows the tests performed by the subjects in all 5 studies included in the review.

3.3. Data analysis:

3.3.1. Subjects data

Table 1. DATA of subjects in 5 studies included in analysis.

Study	Subjects	Excluded	Sex	Age	Weight	Height	Amputation
Gurkan Gunaydin[7]	n=25	n=5	Male (n=20)	25.55 ± 5.17 yrs.	64.93 ± 8.11 kg	175.40 ±5.81 cm	-
Agnieszka M. Nowak et al[9]	n=11	Upper limb amputation subjects	Male (n=11)	28.45 ± 8.73 yrs.	77.10 ± 13.36 kg	177.82 ± 7.11 cm	-
Aya Miyamoto et al[10]	n=18	-	Male (n=18)	37.7±5.7 yrs.	63.2±9.7 kg,	171.9±6.6 cm,	-
Marta Wierczorek et al[2]	n=13	Goalkeepers (upper limb amputation)	Male (n=18)	26.1 ± 7.7	70.5 ± 14.9	175.4 ± 7.6	Above knee (n=4) Below knee (n=7)

							Anomalies in thigh bone (n=2)
GurkanGunaydin[5]	n=15	Surgery last 6 months	Male (n=15)	26.73±5.43	66.40±6.90	174.93±5.13	Left (n=9) Right (n=6) Above knee (n=3) Knee disarticulation (n=3) Below knee (n=9)

3.3.2. Tests

Table 2. Tests performed by subjects in 5 studies included in analysis

Study	Tests	Apparatus	Position	Results (mean ± SD)
Gurkan Gunaydin[7]	One leg hop (cm)	No data	Standing	214.70 ±13.50
	Sprint performance (s) (10m, 20m, 30m)	No data	Standing with crutches	2.20 ±0.22 3.81 ±030 5,37 ±0.41
	Shuttle run (s)	No data	Standing, acceleration every 1-min	304.60 ±71.19
	Strength test(N)	Lafayette-Manual Muscle Tester	Shoulder flexion Sitting– arm 90 degree flexion	236.39 ±36.74
			Shoulder abduction Sitting – arm 90 degree abduction	238.06 ±32.75
			Shoulder extension Prone – lifting arm back	201.18 ±22.30
			Latisimus dorsi Sitting – elbow 90 degree flexion, shoulder internal rotation and 30 degree extension	183.14 ±27.93
			Elbow extension Prone – shoulder and elbow 90 degree flexion	201.18 ±22.30
			Serratus Anterior Supine – Elbow full and shoulder 90 degree flexion	186.28 ±24.94

			Upper Trapezius Sitting – elevating shoulder	173.68 ±22.26
Agnieszka M. Nowak et al[9]	The 30-s Wingate Anaerobic (W)	Arm-crank ergometer (LODE ANGIO, Groningen, Netherlands, Software Package-Wingate v.1.07b)	Sitting position	F= 484.00± 45.86 D= 565.50 ± 134.08
	20-m Sprint (s)	Microgate® photocells	Standing with crutches behind the starting line	F= 8.00 ± 2.70 D= 5.43 ± 1.57
Aya Miyamoto et al[10]	30 m sprint (s)	Video camera (30 fps)	Standing with crutches	6.66 ± 0.38
	Counter movement jump (cm)	Digital jump meter (T. K. K. 5406)	Standing, only healthy leg, arms on waist	31.0 ± 4.4
	60 sec. pushup (times)	No data	Standard push-up position	52.3 ± 16.1
Marta Wierczorek et al[2]	Hand grip strength (kG)	SAEHAN hydraulic hand dynamometer	Sitting, arms along the body, elbow 90 degree flexion	Right hand grip – 45.9 ± 12.6 Left hand grip – 45.6 ± 10.4
	30 m run (s)	Fusion Smart Speed System	Standing with crutches	5.47 ± 0.29
Gurkan Gunaydin[5]	Scapular Endurance (s)	Dynamometer (Feta ® F0202 1 KG/10N capacity/Turkey)	Sit, flexion 90 degree flexion of shoulder and elbow	59.60±24.21
	Core endurance (s)	No data	Modified bridge test	100.64±27.44

3.3.3. Results: There is a significant relationship between upper limbs engagement and performance in amputee football players [2][5][7] [10]. In his study, Gurkan Gunaydin [7] states the relationship between the latissimus dorsi strength and 10 and 20 m sprint. He also stated the correlation of shoulder extension and one leg hop with 30 m sprint. However, Agnieszka M. Nowak et al[9]. came to conclusion that no significant relationship between the upper limb's power and locomotion speed was found. While both studies conducted a sprint test, different methodologies were used to measure the outcomes of the muscle strength and power[7][9]. Aya Miyamoto et al[10]. shows in the study the significant correlation between the duration of the 30 m sprint and the number of push-ups.

4. Conclusion

Regular physical activity reduces the risk of lifestyle related diseases and has positive effects in improving balance, increasing muscle strength and overall physical fitness in amputees[1]. Amputee football is an activity that was initially created for recreational purposes for the disabled, but by the time it turned into a professional branch in many countries[3]. Similar to normal football, amputee football has same rules and requires a high

level of endurance, strength, flexibility, coordination, balance and spinal stabilization. In opposition to normal football, the pitch dimensions are different and field football players use crutches to play[5]. Regarding to the cycle of running with crutches, it is divided into 4 stages, whereof we observe the usage of upper body 33% of the time[1]. Hereby, crutch support must affect the running speed and sports performance.

Gurkan in his study observed that sprinting performance at 10, 20 meters associated with latissimus dorsi muscle and one leg hop performance, and 30-meter sprint with shoulder extension strength and one leg hop performance.[7]A relationship between upper extremity and sports performance was also accepted by Requejo et al., who in their study examined the upper extremity kinetics in the use of crutches and at the end of the crutch swing phase, the shoulder had 10 degrees of abduction and 20 degrees of flexion angle. These angles turned into 0 degrees of extension and adduction at the beginning of the crutch swing phase. Requejo et al. also stated that 15-25 degrees of humeral internal rotation was present during these phase transitions[11].

In the literature included for analysis in this study, it was observed that 4 studies show significant relationship between the upper limb's strength running speed. While one of the studies, did not show a significant relationship between the upper body strength and running speed.

With this study, we observe that despite the popularity of the amputee football, there is a lack of literature in training and sports performance related to it. In accordance with the literature analyzed, there is a relationship between upper strength and muscle engagement with running speed and performance. To improve these qualities of an amputee football player, it is recommended that training programs should include upper body strengthening exercises.

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