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Effects of a Reathletization protocol after ACL ligamentoplasty on performance of Algerian professional soccer player: A case study

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Abstract

Purpose: this study checks the effects of the reathletization protocol following anterior cruciate ligament (ACL) reconstruction in each of the anthropometric parameters, muscle strength and aerobic capacity.

Material & Methods: we present a 12-weeks case-study account for an Algerian professional soccer player participated in this study (age: 21 years, height: 1.71 m, weight: 62.5 kg, body mass index: 21.37 and %body fat: 9.17%).

Results: the authors have comparing the results recorded in measurements and tests before and after 12-weeks of reathletization protocol applied to the professional soccer player, which was intended. First: anthropometric parameters; weight increased by (+3.6 kg, +5.76%) and body mass index by (+1.23, +5.75%). % body fat had decreased by (-1.8 kg, – 19.62%). Their thigh perimeter at 10 and 15 cm from the patella had increased respectively ((injured side; at 10 cm (+4 cm, 9.75%) and at 15 cm (3cm, 6.83%)), ((healthy side; at 10 cm (+2.5 cm, 5.61%) and at 15 cm (2.5 cm, 5%)). Second: muscle strength tests increased in; Prone plank test (1.14 min, 52.77%). Countermovement jump (14.68 cm, 45.66%). Single-leg jump (healthy side; 0.57 cm, 39.04%), (healthy side; 0.1 cm, 4.76%) and Two legs jump increased by (0.43 cm, 22.63%). Third: aerobic capacity; intermittent fitness test increased in: IFT; (2.5 km/h, 14.28%) and maximal O_2 consumption (5.65 mL/min/kg, 11.85%). Heart rate measurements decreased in maximum HR (10 bpm, 5.26%), and resting HR (10 bpm, 16.66%).

Conclusions: after 12-weeks of reathletization protocol, the statistics values indicated a greater significant improvement in the performances of the soccer player. A study with larger population should be undertaken.

Keywords: return to sport, Injury, physical and anthropometric parameters.

Анотація

Хоуар Абделатіф, Касем Абдельхаді, Гуемріче Насредін, Зауї Абделькадер, Чиха Фуад, Зерф Мохамед. Вплив реатлетизації за протоколом після лігаментопластики передньої хрестоподібної зв'язки на працездатність алжирського професійного футболіста: тематичне дослідження. Мета: у цьому дослідженні перевіряється вплив реатлетизації за протоколом після реконструкції передньої хрестоподібної зв'язки (ПКС) на кожен з антропометричних параметрів, силові та аеробні показники. **Матеріал та методи:** подано звіт про 12-тижневе тематичне дослідження алжирського професійного футболіста, який брав участь у цьому дослідженні (вік: 21 рік, зріст: 1,71 м, вага: 62,5 кг, індекс маси тіла: 21,37 і % жиру: 9,17%). **Результати:** автори порівняли результати вимірювань та тестів професійного футболіста до та після 12-тижневого застосування реатлетизації за протоколом. По-перше, збільшилися результати в антропометричних параметрах: вага збільшилася на (+3,6 кг, +5,76%), а індекс маси тіла на (+1,23, +5,75%), відсоток жиру в організмі зменшився на (-1,8 кг, - 19,62%), збільшилися параметри стегна на 10 і 15 см від колінної чашечки відповідно – ушкоджена сторона: на 10 см (+4 см, 9,75%) та на 15 см (3 см, 6,83%), здорова сторона – на 10 см (+2,5 см, 5,61%) та на 15 см (2,5 см, 5%). По-друге, збільшилися результати в силових тестах: планка лежачи (1,14 хв, 52,77%), стрибок з контррухом (14,68 см, 45,66%), стрибок на одній

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Ключові слова:
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нозі (ушкоджена сторона: 0,57 см, 39,04%), (здорова сторона: 0,1 см, 4,76%) та стрибок на двох ногах збільшився на (0,43 см, 22,63%). По-третє: зміни аеробних можливостей, інтервальний фітнес-тест (ІФТ) збільшився на (2,5 км/год, 14,28%) та максимальне споживання O_2 (5,65 мл/хв/кг, 11,85%) Показники роботи серця знижувалися при максимальній ЧСС (10 ударів на хвилину, 5,26%) та ЧСС у спокої (10 ударів за хвилину, 16,66%). **Висновки:** після 12 тижнів реатлетизації за протоколом статистичні дані свідчать про значне покращення результатів футболіста. Надалі слід провести дослідження з більшою вибіркою.

Introduction

Soccer offers multiple physiological and psychosocial benefits, but unfortunately the risk of injury is also high (Larruskain et al., 2018). In professional soccer, injuries have a significant impact on athletic performance, the economy, and player health (Zouhal et al., 2021).

The ultimate goal of professional soccer clubs is to win games, titles and trophies. Avoiding injuries is critical to the team's success; a low number of injuries allows coaches to have the most complete roster (usually about 25 players from which to choose the 11-member team) for training and matches (Ekstrand et al., 2021). In fact, others (Ndgglund et al., 2013)(Eirale et al., 2013)(Arnason et al., 2004) have already shown that injuries negatively affect performance and that a lower injury rate is related to success in national and international matches. Hence, avoiding injuries is of utmost importance (van Mechelen et al., 1992).

In professional soccer, lower extremities are the most common body part prone to injury (84.1%) (Zouhal et al., 2021). Anterior cruciate ligament (ACL) sprains (Duval, Lehance, et al., 2017) and rupture are the most frequent knee injury incurred during participation in sports and especially in football (Alizadeh et al., 2022).

Rupture of the anterior cruciate ligament (ACL) is usually due to a forced movement beyond the ligament's ability to resist, sudden stops or changes in direction (Picard et al., 2021) jumping and landing (Ampatzis et al., 2021). It is rightly considered as the most common serious knee injury associated with sports activity (Rodineau, 2014). One of the reasons for a ligamentous knee injury and repetitive trauma in the joint is a decreased static and dynamic postural control of the lower limb (Grueva-Pancheva & Stambolieva, 2021).

ACL rupture is one of the most serious injuries associated with participation in football (soccer), (Montalvo et al., 2019) and sometimes career threatening injury for the male professional football player. ACL injury can have serious consequences for activity level and quality of life (Montalvo et al., 2019).

Reconstruction of anterior cruciate ligaments (ligamentoplasty) causes anthropometric and muscular deficits in all athletes (Puig et al., 2010) as well as a decrease in physical performance, according to (Laboute et al., 2013) the deficit in isokinetic muscle strength on the quadriceps ranges according to the different studies from 23 to 40% at 6 months and from 15 to 20% at 12 months after the intervention. Many athletes with ACL-injuries have experienced changes in their body composition, such as weight gain (Montalvo et al., 2019) and increased body-mass and fat, as well as imbalances between healthy and injured-sides (Laboute et al., 2013).

The return to sport (RTS) continuum is based on a progression defined by three objectives: return to (participation, sport and performance)(Albano et al., 2021) (Onofrio et al., 2020).

To date, the process of returning to sport after ACL reconstruction is largely time-based, requiring a progressive rehabilitation phase (Kostrub et al., 2020) and defining goals that are the same and achievable (Albano et al., 2021).

Reathletization is an integral part of the rehabilitation of athletes who has suffered the effects of de-training. in order to make him/her physically and mentally fit for a return to competition as soon as possible (Duval, Lehance, et al., 2017). Such a reathletization program requires time, equipment and a specific follow-up (Picard et al., 2021).

Hagglund et al. report that a reathletization program conducted by fitness trainers with soccer players results in a 66% decrease in the risk of new injuries the next season (Ndgglund et al., 2007).

In Africa, no study has addressed the problem of soccer injuries either in terms of statistics or in terms of proposed reathletization programs.

Therefore the purpose of this study was to propose a reathletization protocol for an Algerian professional soccer player who has undergone ACL surgery to allow him to return to sports performance and reduce the risk of re-injury. The second objective is to estimate the effect of this protocol in improving the muscular strength and aerobic capacity of the player, as well as the effectiveness of this protocol in reducing the imbalance of strength and muscular volume between the healthy and injured sides.

Material and Methods of the research

Participants

A forward soccer player (Age 21 years) sustained a non-contact injury to his left knee. (Total ACL rupture). He underwent an ACLR surgery. His characteristics are presented in (Table 1).

Participant Player Consent Statement:

"I am indicating my consent to participate in the research. I understand that the data collected from my participation will be used primarily in a scientific article and I agree to its use in this way".

Table 1

Demographic characteristics of study sample

Age	Height (cm)	Weight (kg)	BMI	% body fat	Level
21	1.71	62.5	21.37	9.17%	Professional

Note: BMI: Body Mass Index

Study protocol

The return of a soccer player from an ACL injury can be a long and difficult process, which is the case in our study, although the player may have recovered in medical terms after 6-months of ACL surgery (i.e. improvements in flexibility, range of motion, functional strength, pain, neuromuscular control, inflammation), preparation for competition requires restoration of strength, power, speed, agility, and aero-anaerobic endurance to exposed levels in soccer. The return from injury is a process that requires additional work on the part of the injured player to regain competitive ability. The player has expressed his willingness to start our reathletization protocol during the period of (02/10/2021 to 25/12/2021), according to the methodology divided into four important phases and organized according to the capabilities of teamwork and the level of the player, which are as follows: Phase

I, Functional Strengthening: (Improvement of strength levels in specific contraction pattern regimes). Phase II, Freedom of Movement: (Stretching: restoring length for optimal range of motion). Phase III, Muscle Balance: (Processing agonist/antagonist force relationships (regulating and braking movement)). Phase IV, Motor Support: (Motor skill training/physical integrity). For more details on the reathletization protocol, see (Fig.1).

Anthropometric measurements & physical tests

Skin folds

Harpenden skinfolds caliper (Model C-136 England) were used to assess the thickness of the skin folds of the biceps, triceps, subscapular area, and suprailiac area, following the method described by Weiner et al. All skin folds were assessed twice and averaged. If the two measurements of a skinfold differed by >1.0 mm, the skinfold was measured a third time and the average of the three values was calculated (Van Der Wijden et al., 2013). The percentage of body fat was estimated by using the method of Durnin and Womersley (Joshi et al., 2008)

Thigh perimeter.

Thigh perimeter was measured by experienced football fitness coach with a medical tape measure at 10 cm and 15 cm from the top of the patella of each limb. The difference and % in the values thereby recorded before and after the reathletization protocol was calculated (Laboute et al., 2013).

Heart rate measurement.

The maximum HR was recorded immediately after the 30-15 IFT, and the resting HR was recorded immediately after awakening using a portable heart rate monitor (Polar® Team2 Pro, Kempele, Finland).

The single-leg (hopping) long jump.

Three maximal long jumps on the healthy limb and on the injured limb were performed turn by turn. The first jump began with the healthy limb. After each jump, the patient returned to the starting line, changed sides (or legs) and carried out another trial. The figures recorded for each limb were measured in centimeters. The mean figure was then calculated for the three jumps with the healthy limb and the three jumps with the injured limb. Expressed in percentage, the mean difference in jump length between the healthy side and the injured side provides simple quantification of the strength deficit on the injured side (Laboute et al., 2013).

Two legs jump.

Standing Long Jump, A LJ test was used in this study to test the anterior non rebounding jumping ability (explosive strength capabilities of the leg musculature) (Minerva Medica, n.d.). Player performed 1-maximal bilateral anterior jump with arm swing. Jump distance was measured from the starting line to the point at which the heel contacted the ground on landing. The validity and reliability of this test were previously reported in literature (Cardinale et al., 2004).

Countermovement jump.

The starting position for the CMJ was a standing position with a straight torso and fully extended knees with feet shoulder width apart (Holsgaard Larsen et al., 2007). Participants

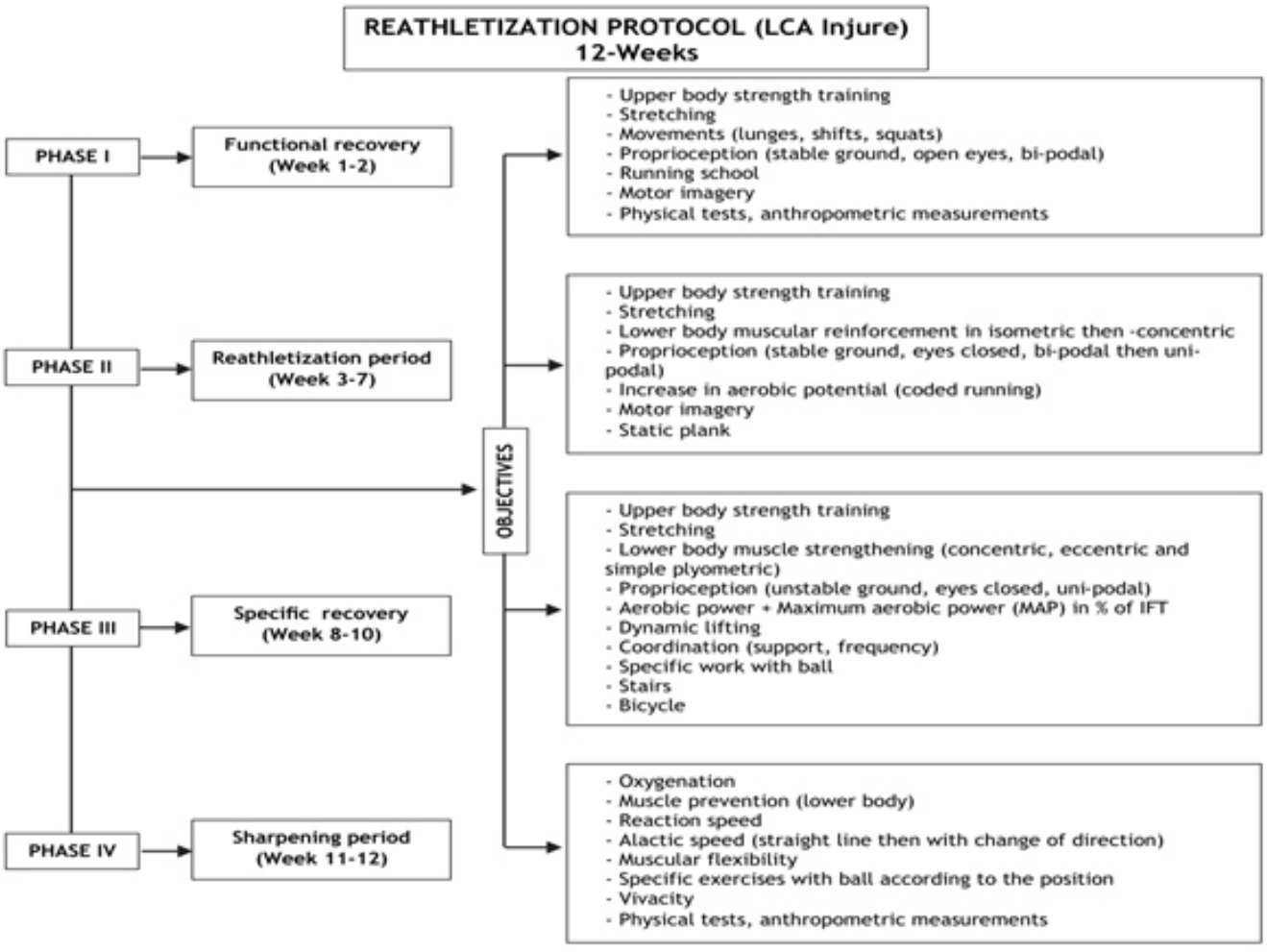

Fig.1. Show the details of the reathletization protocol

kept their hands on their hips throughout the jump. They were instructed to perform a rapid downward movement (approximately 90^0 of knee flexion), and afterwards a rapid upward movement to jump as high as possible.

Prone Plank Test.

For the prone plank test, player maintains a prone position in which the body mass was supported by the toes and forearms. Player was instructed to maintain a neutral position of the spine and pelvis and to breathe normally during testing. Elbows were directly below the shoulders, and forearms and fingers were extending forward, while the feet were kept shoulder-width apart. Each test was ended when the player was unable to maintain their posture or their pelvis moved up or down 5 or more centimeters. Each holding time was recorded using a stopwatch. The holding time (seconds) of the prone plank test was used for further analysis. The reproducibility of this test has been confirmed in previous studies (Tong et al., 2014),with reported ICC values of 0.99 (95% confidence interval 0.98–0.99) and (coefficient of variation [CV]) 2.0 6 1.56% (Љimenko et al., 2019).

The 30-15 IFT.

The 30-15 IFT consists of 30-s shuttle runs interspersed with 15-s passive recovery periods. Velocity is set at 8 km/h-1 for the first 30-s run, and speed is increased by 0.5 km/h every 30-s stage thereafter (well-trained players can start the test at 10 or even 12 km/h to save time). Players are required to run back and forth between two lines set 40 m apart at a pace, which is governed by a prerecorded beep. The prerecorded beep allows the players to adjust their running speed when they enter a 3-m zone placed in the middle and at each extremity of the field. During the 15-s recovery period, players walk in a forward direction towards the closest line (at either the middle or end of the running area, depending on where their previous run had stopped); this line is where they will start the next run stage from. Players are instructed to complete as many stages as possible and the test ends when the players can no longer maintain the required running speed or when they are unable to reach a 3-m zone in time with the audio signal for three consecutive times. The velocity attained during the last completed stage, determined as the player's VIFT. VO_2 max can be estimated from the VIFT according to the following formula: VO_2 max 30-15 IFT($ml.^{-1}min.kg^{-1}$) = 28.3 - 2.15 G -0.741 A -0.0357 W+0.0586 A x VIFT +1.03 VIFT, where G stands for gender (female = 2; male = 1), A for age, and W for weight (Buchheit, M, 2015).

Statistical analysis

The statistical treatment of our data was done by using the formula percentage of variation between the pre-tests and the post-tests by the following formula: ((New value–Old value) / Old value x 100)). The calculations were performed on Microsoft Excel 2007 licensed (KGFVY-7733B-8WCK9-KTG64-BC7D8).

Results of the research

Table 2 presents the results obtained by the anthropometric measurements done on the professional soccer player before and after the reathletization protocol. We have recorded an evolution in % in weight (kg) increased by (+3.6 kg, +5.76%) and body mass index by (+1.23, +5.75%). % body fat had decreased by (-1.8 kg, -19.62%).

Table 2

Evolution of anthropometric parameters (between beginning and end of protocol: Weight, BMI and %body fat)

Anthropometric parameters	Before	After	Difference	Percent variation
Weight (kg)	62.5	66.1	+3.6	+5.76%
BMI	21.37	22,60	+1.23	+5.75%
%body fat	9.17%	7.37%	–1.8	–19.62%

Table 3 presents the results obtained by the thigh perimeters measurements and horizontal jump done on the professional soccer player before and after the reathletization protocol. We have recorded an evolution in % in his thigh perimeter at 10 and 15 cm from the patella that had increased

Table 3

Evolution of thigh perimeters and horizontal jump. (Difference between beginning and end of protocol for the following parameters: thigh perimeter at 10 cm, 15 cm and single-leg jump)

	Thigh perimeter at 10 cm				Thigh perimeter at 15 cm				Single-leg jump			
	Before	After	D_1	Percent variation	Before	After	D_1	Percent variation	Before	After	D_1	Percent variation
Is	41	45	+4	9.75%	47	50	3	6.83%	1.46	2.03	0.57	39.04%
Hs	44.5	47	+2.5	5.61%	50	52.5	2.5	5%	2.10	2.20	0.1	4.76%
D_2	7.86%	4.25%	-	-	6%	4.76%	-	-	30.47%	7.72%	-	-

Note: Is: Injured side, Hs: Healthy side, D_1: Difference, D_2: Deficit

Table 4

Evolution of muscle strength in % before and after the reathletization protocol

Tests		Before	After	Difference	Percent variation
Prone Plank Test	min	2'.16"	3.30	1.14	52.77%
CMJ	cm	32.15	46.83	14.68	45.66%
Two legs jump		1.90	2.33	0.43	22.63%

Note: CMJ: Countermovement Jump.

Table 5

Evolution Evolution of aerobic capacity. (Between beginning and end of protocol for the following parameters: IFT, Vo2 max, maximum-HR and resting HR)

	Tests		Before	After	Difference	Percent variation
30-15 IFT	IFT	km/h	17.5	20	2.5	14.28%
	Vo_2 max	mL/min/kg	47.65	53.30	5.65	11.85%
Heart rate	Maximum HR	bpm	190	180	10	5.26%
	Resting HR		60	50	10	16.66%

Note: IFT: Intermittent Fitness Test, Vo2 max: Maximal O2 consumption, HR: Heart Rate

respectively ((injured side; at 10 cm (+4 cm, 9.75%) and at 15 cm (3cm, 6.83%)), ((healthy side; at 10 cm (+2.5 cm, 5.61%) and at 15 cm (2.5 cm, 5%)). Regarding single-leg jump we have recorded an evolution in % in ((injured side; (0.57cm, 39.04%)), and ((healthy side; (0.1 cm, 4.76%)).

Table 4 presents the results obtained by the muscle strength tests done on the professional soccer player before and after the reathletization protocol. We have recorded an evolution in % in the Prone Plank Test (1.14 min, 52.77%), Countermovement jump test (14.68 cm, 45.66%), and Two legs jump test increased by (0.43 cm, 22.63%).

Table 5 presents the results obtained by the aerobic tests and measurements done on the professional soccer player before and after the reathletization protocol. We have recorded an evolution in % in the 30-15 IFT increased in: IFT (2.5 km/h, 14.28%), and Vo2 max (5.65 mL/min/kg, 11.85%), heart rate measurements decreased in maximum HR (10 bpm, 5.26%) and resting HR (10 bpm, 16.66%). For further clarification on the results of our study, see (Fig. 2).

Discussion

The results of our study confirm the effectiveness of the reathletization protocol and show a significant improvement over the course of the protocol in anthropometric parameters, volume and muscle strength and aerobic capacity. More exactly, the body weight increased by (+3.6 kg, 5.76%), this evolution in body weight had a positive impact on the body mass index, which reached 22.6 after the protocol with a difference of (+1.23, 5.75%). This increase is explained by the muscular hypertrophy because of the various muscular solicitations in particular in the 3rd stage (Specific Recovery). Body fat undergoes a greater decrease (-1.8 mm, -19.62%), this decrease in body fat percentage is due to the running work (coded and uncoded) during most of the reathletization period.

In comparison, the anthropometric values of our player after the reathletization phase are close to the values of high level footballers. Regarding weight (Zouhal et al., 2021) found

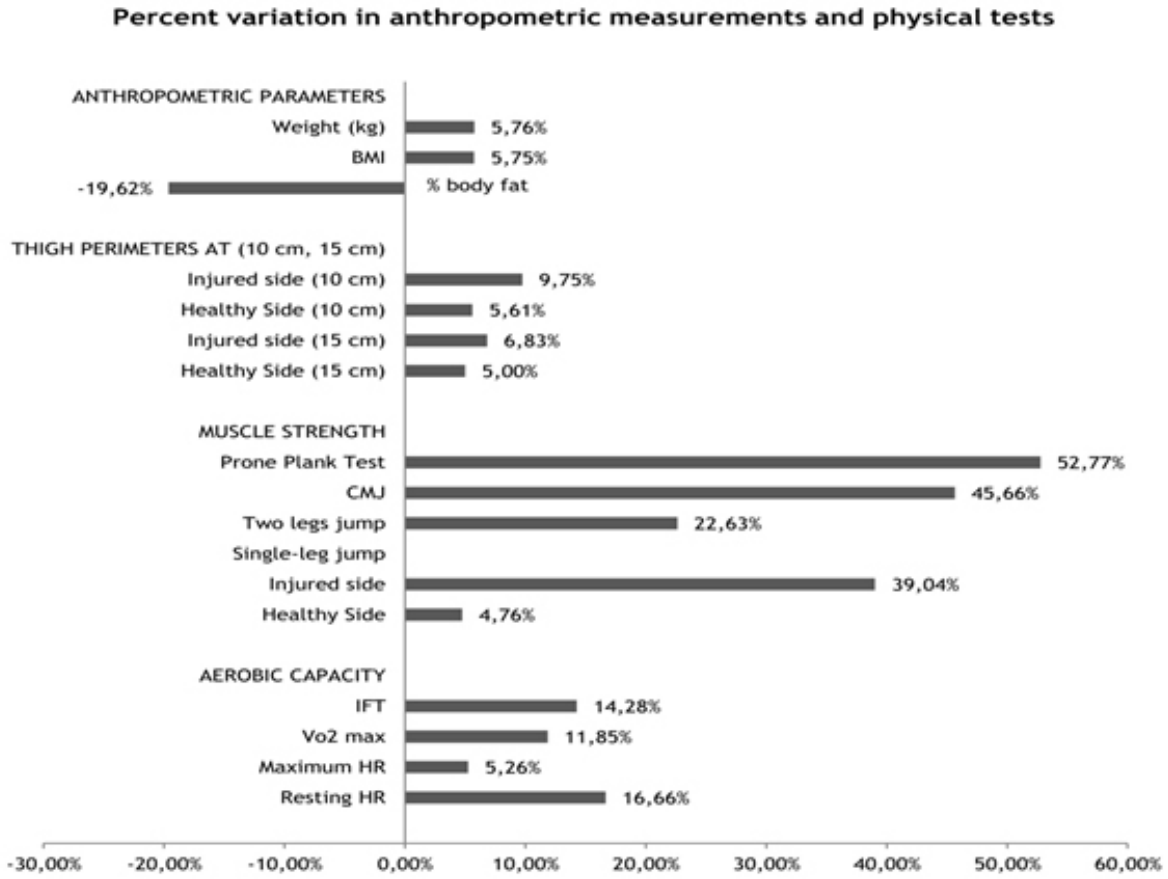

Fig. 2. Show the variation between the beginning and the end of the reathletization protocol in the anthropometric measurements and physical tests

that professional soccer player weighs 69.1-81.3 kg (66.1 kg for our player). Depending on the study, the fat mass of a player is between 7.5 (Owen et al., 2018) and 13.6% (Clemente et al., 2019), (7.37% for our player). The Body Mass Index (BMI) of soccer players is between 22.9 (Ingebrigtsen et al., 2012) and 24.1 kg/m^2(de Araљjo et al., 2019) (22.6 kg/m^2 for our player).

More than 80% of professional soccer club physicians surveyed in the study by (Delvaux et al., 2015) considered muscle strength among the most critical criteria for returning to competition after ACL plastic surgery to ensure a safe RTS. A remarkable progression in volume and muscle strength, thigh perimeter at 10 cm increased (4 cm, 9.75%) in the injured side and (2.5 cm, 5.61%) in the healthy side,thigh perimeter at 15 cm also increased by (3 cm, 6.83%) in the injured side and (2.5 cm, 5%) in the healthy side. These gains in muscle volume are greater than that of (Laboute et al., 2013), who achieved 1 cm following a program of rehabilitation and leucine supplementation following ACL surgery. The muscle strength of the injured leg evolved by 39.04%, and the injured leg evolved by 4.76%, this great difference in evolution is due to the great loss of strength after the ACL surgery. Condouret et al. showed the persistence of an average strength deficit of 10% (Duval, Lehance, et al., 2017) to 20% (Delvaux et al., 2015) in the quadriceps and hamstrings. The bilateral deficit of our player is up to 30.47%, this deficit was expected, because the deficit in isokinetic muscle strength on the quadriceps ranges according to the different studies from 23 to 40% at 6 months (Laboute et al., 2013), we see that this great deficit is due to the total cessation of physical activity following ACL reconstruction and the long period and delay in the beginning of the process of reathletization. But through this later, we were able to reduce the bilateral deficit in muscle strength up to 7%, this value allows a more secure RTS, where 36% of doctors tolerate up to 10% of bilateral difference as an essential criterion of RST (Delvaux et al., 2015) and it is essential to decrease these muscular deficits (Paterno et al., 2018), whether it is the strength of the hamstrings(Thomas et al., 2013), which protect the transplant, or of the quadriceps, which is correlated with persistent pain (Cristiani et al., 2020) or recurrence (Schmitt et al., 2015).

The quantified values for our player indicated a greater improvement in the muscular strength performances. The player progressed in terms of general strength after the reathletization protocol, he was able to exceed 3 min of sheathing, and this performance gave him self-confidence to return in competition.

Regarding the vertical jump measured by the basis of the CMJ test, and the horizontal jump measured by the basis of the Two legs jump test, the results obtained in the pre-test show the player's weakness in lower limb strength (Duval, LEHANCE, et al., 2017), and reflect the effect of the cessation of physical activity after the ligamentoplasty, as well as the player's fear of a new ACL rupture during squatting, jumping and landing activities(Schmitt et al., 2015), that's why psychological support is mandatory in this phase (Picard et al., 2021), (Johnson et al., 2016). Plyometric is often included in reathletization (Grueva-Pancheva & Stambolieva, 2021), especially in phase 3 allowing the player to make significant progress and reach the values of professional players who have a CMJ performance between 33.6 (Fernando et al., 2016) and 43.3 cm (Arcos et al., 2017).

Shuttle running is an integral part of professional soccer, a long period of inactivity decreases aerobic performances (Duval, LEHANCE, et al., 2017), the IFT test shows the preparation of the patient for a return to competition, the player showed no pain or fear of re-injury during the test, he presented a V_{ift} value of 20.5 km/h at the end of the protocol and a VO_2 max value of 53.30 ml/min/kg, these values are acceptable to return to competition, where the VO_2 max of the professional players is between 56.8 (Owen et al., 2018) and 59.4 ml/min/kg (Koundourakis et al., 2014). This VO_2 max value allows the player to sustain high-intensity efforts and to optimize recovery between efforts (Zouhal et al., 2021). The maximum heart-rate and the resting heart rate were influenced by this reathletization protocol, they decreased by 10 pulses/min, reflecting the good physiological responses related to this reathletization protocol.

Conclusions

A progressive protocol after 6 months of ACL surgery allows a complete recovery of the patient and a safer return to competition. A 12-week protocol is adequate for optimal reathletization, and allows: developing strength and aerobic performance, presenting a lower risk of recurrence and reducing bi-lateral deficits.

The results obtained are pertinent to the monitoring of the functional status of football players after ACL ligamentoplasty.

We feel it is important to emphasize the weakness of our sample (one subject) which limits the statistical power of our study. Further studies with a larger number of subjects are still necessary.

Author Contributions

Houar Abdelatif: data collection/entry, data analysis/statistics, data interpretation.

Kacem Abdelhadi: study design/planning, data interpretation.

GuemrichE Nasredine: data interpretation, fundraising.

Zaoui Abdelkader: data collection/entry, literature analysis/search.

Chiha Fouad: data interpretation, fundraising.

Zerf Mohamed: data analysis/statistics, data interpretation, fundraising.

Conflicts of Interest

The authors declare no conflict of interest.

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