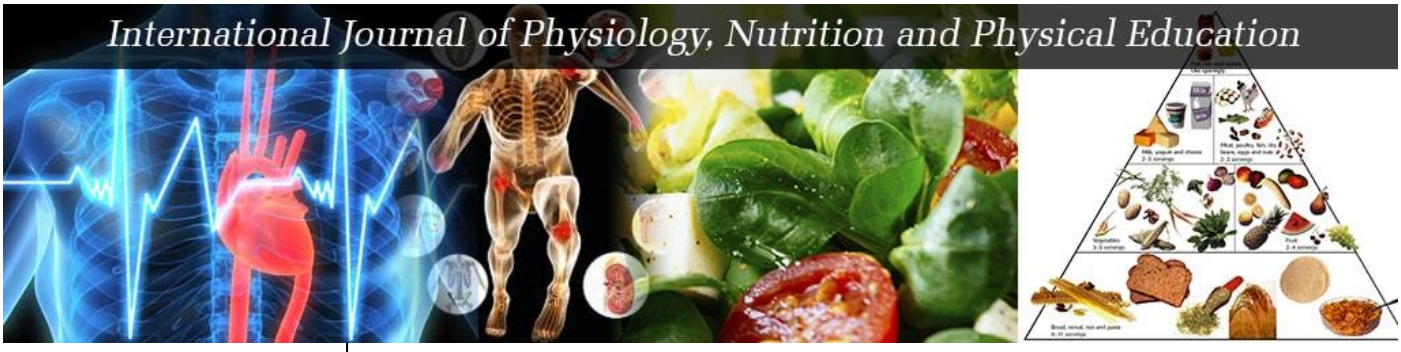

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Recovery of muscular function of the upper limbs after three series of repeated shooting exercises in handball players

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Abstract
This study is of an experimental type, which concerns fourteen (14) handball players whose aim is to better understand the effects of the recovery of muscle function after three sessions of repeated shots (TTR) before after 24 hours and 48 hours. The subjects were randomized into two experimental groups of 24 hours and 48 hours. The TANITA method by analyzing the bioelectrical impedance of the subjects' body composition measurement and armband Myo-test made it possible to evaluate the performance related to muscle recovery from series of repeated shots (STR). The results obtained show that: the number of hours necessary for the muscle function of the upper limbs to recover better is 48 hours than 24 hours for STR. These results are respectively: CTR (123, 42±20.99 watt vs 101.07±21.174 watt), and TTB (07.21±01.02 vs 05.71±01.20l). However, the evolution of performance in the repeated shooting test during the confrontations between GE1 (48h) vs GE2 (24h), show significant differences, 22 goals in Vs 15 goals in favor of 48h rest. We suggest that coaches and physical trainers take these results into account to better optimize shooting performance during a competition, to better schedule competitions and manage squad numbers. This is to avoid muscle overload and lower shooting performance.

Keywords: Muscle recovery, repeated shots, handball

Introduction
The optimization and development of the athlete's performance capacity involves that of the determining physical qualities in the activity, the most important of which are speed, explosiveness, motor coordination, maximum aerobic power and recovery capacity. Inter-effort. Added to these qualities is the capacity for repeated shots (Bishop *et al*., 2011; Buchheit *et al*., 2010) [3, 5]. Which is increasingly highlighted. This ability to repeat shots (CTR) is indeed currently considered one of the main physical determinants of performance in team sports because without shooting, there are no scores (goals) let alone victory. In handball, matches are characterized by high intensity actions such as high-speed runs, jumps, shots, blocks, changes of direction (Gorostiaga *et al*., 2006) [14]. It is therefore no longer a simple game, because its universal character induces constraints for both players and coaches. To meet everyone's expectations, the players are subjected to a very high work rate during matches and training sessions. Based on these studies, Bishop *et al*. (2011) [3] suggested two strategies to develop CTR. The rest time between two training sessions is indeed one of the main parameters to be controlled by the trainer. This rest time represents the time necessary to ensure the restoration of muscle function after each type of training. The recovery times that have been the subject of the most experimental work are rather those scheduled between exercise sequences during a session (Bishop *et al*., 2008; Balsöm *et al*., 1992a) [4, 1]. The present study makes it possible to compare the impact of sessions in 24 hours and 48 hours aimed at developing CTR on performance in shooting tests with precision and also to compare the levels of restoration of performance in shooting tests (TTR), after 24 hours and 48 hours of rest, Under these conditions, it seems quite appropriate that to develop CTR in adolescents, it is necessary to use not only sessions that combine sprints and muscle strengthening of the lower limbs. In Congo, there is almost no study conducted in this area, which is why we propose to conduct this study on recovery after a series of repeated shooting training sessions

in handball players. This is why, to reach the highest level, the physical condition must be very well developed and good recovery is necessary and essential. The recovery of muscle function is essential in high-level sport characterized by twice-daily training and repeated competitions (Cometti, 2009) [10]. For some time now, coaches and players seem to be neglecting this essential part of training, which would consist of recovering better after an intense training session leading to poor performance. This is how the observation of poor performance in the second half of the game with the Red Devils of Congo. This leads us to carry out this study: "The recovery of the muscular function of the upper limbs after three series of repeated shooting exercises in the handball players of the Congo star".

In view of the foregoing, there is reason to question oneself through the main and fundamental question of research which arises as follows: "what are the numbers of hour's necessary for the muscular function of the upper limbs can recover after 24 hours and 48 hours during a repetitive shooting session? To address this concern, we formulate the following hypothesis: "Upper limb muscle function could recover better 48 hours after a session of repeated shooting exercises.

The objective of this study was to evaluate the physical shooting capacity of the upper limbs of handball players after 24 and 48 hours of recovery. This study has the interest of preventing and reducing the risk of injury and muscle fatigue during a competition to better optimize performance.

Material and Methods

1. **Field of research:** The population of thirty-three (33) sports federations existing in Congo, we have chosen the Congolese Handball Federation (FE.CO.HAND). This choice of Etoile du Congo was made by random draw.
2. **Attendees:** The population was composed of twenty-two (22) senior handball players, a sample of fourteen (14) handball players including 07 girls and 07 boys. Certain criteria of choice have been fixed, in fact, the subjects included in our sampling are those who present a normal state of health and a physical and moral health, officially recognized as players of Etoile du Congo, selected among the players participating in the tests, holder of a license and regular in training. However, the excluded subjects are those who did not attend one of the study tests.
3. **Experimental procedure:** The approach was first to begin a familiarization session with the series of repeated shots (TTR), according to the split distances of nine (09) to fourteen (14) meters of goals. This experiment consisted only of this test of repeated pulls according to the positions. Anthropometric parameters (ages, height, weight) were collected. A general and specific warm-up followed by stretching exercises was performed beforehand. The experiment began with a pull test linked to the Tanita device which makes it possible to evaluate the variables of body composition. This test was followed by a ten second maximum recovery at the shooting interval. The first firing test was carried out between two maximum attempts. After this test the subject recovers three minutes before carrying out the repeated firing test.

The second repeated firing test is carried out three minutes later. This test was carried out before and after 24 hours and 48 hours, the Myo-test cuff test. The subjects performed the Myo-test test at the same time as on the first day. During this experiment, verbal encouragement was given to the subjects. The Myo-test, equipped with an accelerometer, measures the power, speed, strength of the upper and lower limbs and the height of the jump. It was placed in the form of an armband around the arm through the belt of the Myo-test.

Shooting practice sessions

The first phase of the classic training (EC), organized in this order in the morning lasted 2 hours. It took place in the open air, at a radiant temperature varying between 29 and 37 °C. The corresponding relative humidity fluctuated between 61% at the start of the session and 39% at the end. These sessions require a significant physical commitment, because they combine muscular endurance, strength-speed, coordination, agility, and visual analysis. All subjects performed a warm-up before starting the training sessions by running at a moderate pace for a period of 10 minutes and a series of specific stretches for five minutes. They finally performed split sprints over 40m (about 80% maximum speed) and accompanied by circumduction movements of the shoulder girdle, abduction, supination for the wrists.

Classic session (SC)

This session is considered the first of a training block aimed primarily at improving the handball player's behavior in defense. It consisted of specific handball exercises, after a 15-minute warm-up. The main part, which lasted 90 minutes, included: three-way pass-receipt exercises and rapid ball upswing followed by shots on target over the calibrated distances of 6m to 14m. Indeed, the shots were made for 75% of this time to better verify the performance of the players during 24 hours and 48 hours of recovery. Then, realization of 25% of the time, counter-attack exercises, recovery of the ball at 1 against 1 and 2 against 2, running and defensive withdrawal, game 1 against 1, shooting trigger. Finally, the real game on the whole field (7 vs 7) to determine by the penalty shootout with precision which each player had the possibility of shooting on ten (10) shots calibrated difference of 1m, whose objective is to perform well in shooting. A return to calm of 5 min was planned at the end of the session.

Session of a game played between the subjects of the 24h and 48h groups.

The two groups compete for 30 minutes with two 15-minute halves, separated by a 7-minute break. To this end, the players must perform an alternation of brief and explosive actions, interspersed with recovery by scoring more goals than the opponent. This part allows to check the impact of the recovery between 24h and 48h and to compare the performances between these two groups.

Measurements taken

Anthropometric variables: Height is the distance between the bottom of the feet and the top of the head. It was measured using a two (2) meter height measuring rod of the "Stanley" brand. The weight (W) of the handball player was evaluated using a "TANITA" brand weigher calibrated in kilograms (kg).

Repeated shot test (TTR)

The TTR test consisted of calibrating the intervals of shots from 7 to 14 meters with a recovery time of 2 minutes between series according to the approach of (Zagatto, *et al*., 2009) [18]. The subject begins the test by stepping on the 7m line while holding the ball. The time is measured, the start of the test is at will after the first series of shots, the subject is invited to recover 2 ammunitions between the series and to answer the same procedure during the three series. We consider a series as being the realization of the six calibrated

shots of 7 m, 9 m, 10 m, 11 m, 12 m, 13 m. The subjects perform three series of shots at different intervals.

Variables studied

The dependent variables were repeated shot ability (CTR), The Accuracy Shots on Goal (TTB) test on a series of six (10) is equivalent.

Numbers of shots combined with the match on, moreover, the confounding variables rectal temperature (Tr), water drunk (water), resting heart rate (HR), average heart rate (HR) reached during workouts, sleep time per 24 hours for the duration of the study, percentage of water loss during each workout and during recovery.

Statistical analysis

Data were processed using IBM SPSS statistics 21.0 software. Means and standard deviations were used for all variables. The normality of the distribution of the variables was verified by the Shapiro-WILK test. The level of confidence was set at 95% and the 5% representing the level of significance of all the statistical tests (p<0.05).

Statistical treatment of the study data was based on the difference in mean Myo-test test performance before and after the series of repeated shots (STR) was obtained by t-test for the paired samples to determine the significant differences between performance measured before, after 24 hours and 48 hours of STR

Results

Table 1: Anthropometric and physical characteristics of handball players before the tests Anthropometric and physical Minimum Maximum Average Standard deviation

Anthropometric and physical	Minimum	Maximum	Average	Standard deviation
Ages (years)	17	34	25.14	05.37
Size (m)	1,57	01.92	01.74	0.07
Weight (kg)	56.5	86.6	68.34	06.09
BMI (kg/m^2)	17.44	23.15	19.58	01.03
GM (%)	05	19.4	09.32	02.94
MM (%)	55	71.5	64.54	04.69
CP	05	09	07.71	00.88
TTB (n)	02	07	04.285	01.382
CTR (W)	57	97.33	78.49	13.72

BMI: Body Mass Index; MG: Fat Mass; MM: Lean Mass; CP: Physical capacity; CTR: Repeated Shot Capacity; TTB: Repeated Shots Test

The handball players are on average 25.14±05.37 years old, whose average height is 1.74±0.07 m, with an average weight of 68.34±06.09 kg and a body mass index of 19.58±01.03 kg/m^2, However, the physical qualities were 5, MG of 09.32±02.94%, MM of 64.54±04.69%, CP of 07.71±.00, 88, TTB of 04.285±01.38, the Capacity of our subjects ranges from 78.49±13.72 watts.

Table 2: Anthropometric and physical characteristics of the subjects after 24 hours of recovery at the STR

Anthropometric and physical	Minimum	Maximum	Average	Standard deviation
Ages (years)	17	34	25.14	05.37
Size (m)	01,57	01,92	01,74	0,07
Weight (kg)	55	85	66,57	07,96
BMI (kg/m^2)	17,73	23,26	19,76	01,06
GM (%)	05	19	08,64	02,78
MM (%)	38	72	62,64	06,21
CP	06	10	08,36	00,79
CTR (W)	80	148	101.07	21.174
TTB(n)	03	08	05.714	01.204

BMI: Body Mass Index; MG: Fat Mass; MM: Lean Mass; CP: Physical capacity; CTR: Repeated Shot Capacity; TTB: Repeated Shots Test.

This table presents the results of the anthropometric and physical data of the subjects after a session of TTR. It emerges that the height does not change, the weight has slightly decreased by (66.57±07.96 kg; BMI 19.76±01.06 kg/m^2; GM by 08.64±02.78%; MM by 62.64±06.21%; CP 08.36±.00.79; CTR 101.07±21.174; TTB0 5.714±01.20).

Tableau 3: Caractéristiques anthropométriques et physiques des sujets après 48h de récupération au STR

Anthropometric and physical	Minimum	Maximum	Average	Standard deviation
Size (m)	01.57	01.92	01.74	0.07
Wieght (kg)	56.5	86.6	68.34	06.09
BMI (kg/m^2)	17.44	23.15	20.00	01.03
GM (%)	05	19.4	09.32	02.94
MM (%)	55	71.5	64.54	04.69
CP	05	09	07.71	00.88
CTR (W)	82	150	123.42	20.997
TTB (n)	05	09	7.214	1.121

BMI: Body Mass Index; MG: Fat Mass; MM: Lean Mass; CP: Physical capacity; CTR: Repeated Shot Capacity; TTB: Repeated Shots Test

This table presents the results of the anthropometric and physical data of the subjects after an STR session. It emerges that the height does not change, the weight slightly increased by (68.34±06.09 kg; BMI 19.58±01.03 kg/m^2; GM of 09.32±02.94%, MM of 62.64±06.21%, CP is 07.71±.00.88; CTR is 123.42±20.99 w; TTB 07.214±01.12).

Table 4: Comparison of the physical performances of the dependent variables during the repeated shot tests (TTR) after 24 hours and 48 hours of recovery

Anthropometric and physical	After 24h				After 48h				t	P
	Min	Max	$\bar{X}$	Δ	Min	Max	$\bar{X}$	δ		
CTR (W)	80	148	101,07	21,174	82	150	113,42	20,99	0,95	NS
TTB (n)	03	08	05,71	01,204	05	09	07,21	01,02	3,5***	p<0,01

CTR: Repeated Shot Capacity; TTB: Repeated Shots Test.

The results of the anthropometric and physical data of the subjects after a repeated shooting session. It emerges that after 48h of STR the players are more powerful than after 48h of recovery after STR (113.42±20.99W vs 101.07±21.174W); Similarly, the test of penalty shootouts (TTB), we contact that the players achieved a good performance in 48 hours that at 24 hours of recovery is TTB 07.21±01.02 against 05.71±01.20 with (p<0.01).

Table 5: Comparison of the physical performance of the variables during the repeated shot tests (TTR) after a 24-hour session and 48 hours of recovery

Physical performance	After 24h		After 48h		T	P
	$\bar{X}$	δ	$\bar{X}$	δ		
CTR (W)	101,07	21,174	113,42	20,99	0,95	NS
TTB (n)	05,71	01,204	07,21	01,02	3,5***	p<0,001

CTR: Repeated Shot Capacity; TTB: Repeated Shot Test

The summary results show that after 48 hours of STR the players are more powerful than after 24 hours of recovery at STR (113.42±20.99 W vs 101.07±21.174 W); the (TTB), a good performance in 48h than at 24h of TTB (07.21±01.02 Vs 05.71±01.20; (p<0.001).

Discussion

The present study focuses on the recovery of muscle function of the upper limbs after the effects of three series of repeated shots in handball player's associates body and physical composition. The aim of our study is to better understand the effects of the recovery of muscle function after three sessions of repeated shots (TTR) can have a considerable impact on the physical condition of the upper limbs of the handball player.

The results obtained can be explained by the fact that the duration and nature of the recoveries between shots during an STR test can affect the maximum shooting speed and metabolic function, and therefore influence the performance of the CTR test. As recovery during a CTR test is important, it would be interesting to assess its impact on CTR performance. CTR is indeed increasingly recognized as a critical performance factor in team sports play, particularly in current handball and basketball Dawson, (2012) [12]. Some studies have also been devoted to strategies for developing and improving CTR in athletes or active people (Bishop *et al*., 2011) [3]. These results show us that the age of the subjects is ideal for playing handball and that their weight is normal for the practice of this sport which is the team sport best practiced after handball. It is therefore reasonable to think that the young handball players solicited for this study have, on average for their age, good potential to reach a good level of ability before entering the training sessions of repeated shots (STR) compared to young handball players by comparing those of the French (TTR) after 24 hours of recovery, the results reveal that: the height does not change, the weight has slightly decreased as well as the BMI; weight (66.57±07.96 kg), BMI (19.76 kg/m^2), MG (08.64±02.78%), MM (62.64±06.21%), CP (08, 36±00.79) CTR (101.07±21.174), TTB (05.714±01.204). These results confirm intense physical efforts induce weight loss due to dehydration. Dehydration does not seem to lead to a decrease in muscle strength, but has a deleterious effect on strength endurance (Bigard *et al*., 2001) [2]. When it occurs during exercise in the heat, it reduces the performance of anaerobic exercise." A loss of more than 2% of weight has a negative effect on aerobic performance. On the other hand Casa *et al*. (2000) reported that dehydration corresponding to a loss of 1% to 2% of body weight already compromises the physiological functioning of the body and affects performance. This is why after a training session of repeated shots (STR) the anthropometric and physical characteristics of our subjects underwent a slight modification. On the other hand, the variables (CTR, TTB) have been increased, hence the improved performance in 24 hours of recovery. Concerning the results of the SETRs after 48 hours of recovery, the results show that the variables (height, weight, BMI, MG, MM, CP) remain constant than those observed in 24 hours, on the other hand, the variables of the performance of our subjects improved significantly either CTR (103.42±20.99), TTB (07.214±01.12). The recovery of muscle function is essential in high-level sport characterized by twice-daily training and repeated competitions Cometti, (2009) [10]. However, the different recovery methods can be used to reduce the time required to regain the athlete's initial level of performance. These results allow us to confirm that after the recovery of 48 hours following the repeated firing session (STR), the developed power CTR is slightly improved but not significantly. However, the TTB increased significantly by (p<0.001) This more or less complete restoration of muscle function of the upper limbs may be associated with the nature of the several shots performed during the STR which require eccentric contractions. Due to the muscle damage that often follows eccentric CTR exercises, the restoration of muscle function can indeed last for several days (Sesboüé & Gineste, 2006) [17]. The data relating to the restoration of CTR performance corroborate those of Eston & *et al*., (2003) [13] who noticed that often 10 to 15% remained to be restored after a recovery of 72 hours following the exercise muscle damage. They also reported the same observation after ultra-marathon, following intense plyometric exercise. It must be recognized that the participants of this study are high level players. They are therefore moderately trained and are used to these types of STRs and training involving muscle building. This moderate level of training, associated with experience, are factors likely

to explain the success of the performance achieved during the STR on the body and physical composition of the most demanded muscles (Bishop, *et al*., 2008) [4]. Indeed, the motivation of players to carry out appropriate recovery modalities after training, may be genetically predisposed to increase recovery times may lead to the use of targeted recovery modalities. Similar results have been other interventions that may improve recovery include cold water immersion and the use of compression garments, although results are currently equivocal. Studies by Sedano *et al*. 2009 [16] showed significant increases in CTR repeat shot ability of (p<0.001, p<0.05, and p<0.01) respectively. To this effect, the improvement of the CTR indicates the adaptations related to the increase in the muscular power of the legs have taken place. Significant improvements are observed in CTR and TTB in the experimental group respectively. On the one hand, fatigue is considered to reflect the inability of skeletal muscles to generate an expected level of force and the performance measured after muscle activity is the net balance between fatigue and post-activation potentiation. On the other hand, there was a positive effect of repeated shots up to the third set. It is generally measured by the Myo-test, which is a device that gauges the muscular power of the upper and lower limbs in terms of capacity. This is an important requirement for the performance of vertical and horizontal relaxation in handball players. Other studies have not reported any significant decreases probably due to a "heating and climatic condition" effect. Performance increases from repeated firing may remain 24 hours, 48 hours and 72 hours after intense exercise but, regardless, 48 hours after repeated firing sets appear to be sufficient to return to baseline levels. Therefore, repeated shots can also be used to indirectly monitor upper limb recovery to improve the performance of high-level handball players.

Reported in other studies (Buchheit *et al*., 2010) [5].

Conclusion

Our series aimed to evaluate the impact of series of repeated shots on the recovery of muscle function in senior Congo star handball players in order to know and compare the rate of restoration after 24 and 48 hours of recovery. These results suggest that coaches and physical trainers take into account STRs to organize specific training blocks based on the use of combined exercises aimed at developing the capacity for repeated shots (CTR) to optimize handball performance. In the case of handball, recovery is essential to chain the matches and to be efficient in shooting during the effort.

Conflicts of interest

The authors declare no conflict of interest regarding the publication of this article.

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