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ASSESSMENT OF PRE-SEASON ANTHROPOMETRIC TESTS OF RUGBY PLAYERS IN A CHAMPIONSHIP CLUB, KENYAN RUGBY UNION

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Abstract:
Objective: The objectives of the present study were to evaluate the anthropometric factors of rugby players on preseason before the onset of the training in a championship club (Kisumu Rugby Rfc **Setting:** The study was carried out in a Kenya at a Kenya rugby union (Kisumu Rfc) championship club. **Sample:** Sampling frame consisting of 52 players who were registered in the club at the time of the study. (*n* =52) **Analysis:** Data were analyzed through descriptive and inferential statistics, linear and multiple regression analyses. **Main measures:** Maximal Aerobic power, demographics and strength tests of back squat and Bench press. **Results:** The estimation of this hypothesized factors that affect maximal aerobic power were age, Primary position, weight, injury F (7,44) =.622, P<.735, R^2=. There was correlation between several factors that affect maximal aerobic factors with the linear regression formula generated being Maximal Aerobic Power (VO_2Max) = 12.12 + (0.49xAge) - (017xWeight) – (0.657xPosition) + (257X FMS™ (z-score) – (0.52x100m) + (.170xPlanks) + (0.37xPush-ups) **Conclusion:** aerobic power (VO_2Max) is influenced by several factors including age of the rugby players, weight of the players and the playing positions of the players. **Recommendation:** Future research should further clarify how preseason testing and anthropometric tests of rugby players would influence the outcome on fitness before the start of the season which the ultimate goal of most rugby players and coaches.

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Keywords: maximal aerobic power, injury, rugby players, bleep test, Kenya Rugby Union, Kisumu

1. Introduction

Rugby is categorized among one of the most demanding sports that require players to make bouts of sprints, tackles and Contact physical collisions (Gabbett, Kelly & Peze, 2007) approximately, rugby players cover a distance of about 8 to 10 km each match and this highly depends on their playing position on the field (Meir, Newton, Curtis, Fardell & Butler, 2001). Rugby union is a contact sport in which players require high levels of physical fitness, composite of aerobic fitness and anaerobic endurance, muscle strength and power, speed, agility and body composition (Hene, Bassett & Andrews, 2011). This places a huge responsibility upon elite players to achieve and maintain good physical fitness pre-and in-season to sustain the physical demands of the game and avoid Injury (Caldwell & Peters, 2009). (*Die samestelling van' n rugbyspeler-indeks vir die suksesvolle evaluasie van rugbyspelers*, 2014) it's important to note that several studies have reported the importance and characteristics fitness of rugby players of several playing levels ranging from the international to junior level (Baker & Nance, 1999; Gabbett, 2002; Baker, 2001; Batterham & Hopkins, 2005). Fitness testing and anthropometric measurement are critical and very useful for assessing and monitoring rugby players.

These studies also provided important information on fitness level, normative data of each group and are used for the development of new young team (Batterham & Hopkins, 2005.) further studies have documented keenly the anthropometric characteristics and physical performance of rugby players to provide the physical qualities required for the optimal performance in rugby (Gabbett, Kelly & Peze, 2007) this underscores the importance of a rugby player attaining ideal physical and appearances and optimum fitness level. Furthermore, rugby is a very high physically demanded game and thus, every rugby player need to be extremely fit. With high physical performance and suitable anthropometric characteristics will definitely contribute to a team total performance (Gabbett, 2002). In rugby union players can be categorized as forwards and backs. Due to the difference in the playing positions in the rugby team, the fitness levels and anthropometry measures of each playing position may differ with each other (Gabbett, Kelly & Peze, 2007). According to a study done by Batterham & Hopkins (2005) it is well reported that forwards tend to be much heavier with greater skinfolds measurements as compared to other position. Besides that, forwards also were found out to be slower in change of direction speed, 20 m sprint and 40 m sprint. These morphological characteristic suits them since they are play a more combative approach in the game compared to the backs. In Kenya, rugby is less popular compared to football/soccer but the sport is popular among university students and high schools. Unfortunately, no database or local norms for the physical characteristics of Kenyan rugby players especially the sub-elite players. These norms are vital for our nation's sports development as programs can be setup to improve the current status.

The study was conducted to among the championship players of Kenya rugby seeking to find out the anthropometric characteristics of the players prior to the start of the preseason. To date, no published study has monitored the physical fitness levels pre-season of Kenya rugby union players in the championship competition; hence, the purpose of our study. This is important because the primary goal of pre-season training is to optimize fitness and enhance performance during in-season competition (Granados, Izquierdo, Ibáñez, Ruesta & Gorostiaga, 2008). Thus, this study will be able to determine the physical characteristics of Kenyan championship rugby players in a selected club using the anthropometric evaluation and a battery of fitness tests which include Bleep test, bench press, Back squat test, 40m Acceleration, 100m Sprint sit and reach test, bleep test, Burpees, one-minute Sit-up and one minute Push-ups test. A FMS™ was utilized to identify the muscle imbalances of the players before commencement of the test. The study hypothesized that there would be a significant difference between the physical fitness characteristics of male rugby players forwards and backs in the championship competition during the pre-season (Gabbett, 2005; Gabbett, King & Jenkins, 2008).

2. Procedure

A. Instruments

The data was collected using protocols which players were asked to fill their basic information, i.e. name, address, medical insurance cover and presence or history of injury on the player. A music system was tested for audibility of the Bleep test. Space markers were used to mark the 100 meters and 40 meters on a relatively flat surface on the rugby pitch. Stopwatches were used to time the 100meters sprint, 40meters acceleration and 1-minute sit-up and push-up test. Weights ranging from 5kgs plates to 20kgs plates were assembled with a chest press bench and a back-squat machine with bars availed. A meter rule and piece of masking tape were used on a flat wooden surface to evaluate the FMS™ on the players. All the results were recorded on the players' protocol form.

B. Subjects

Before testing, institutional ethical procedures were satisfied and informed consent of the club was given to perform the project. A team (Kisumu Rfc) in the championship of the Kenya rugby union (KRU) was purposively selected from the rest of the teams in the championship league for the study. All players who were registered with the team and playing for the team were liable for the fitness testing. All subjects performed this fitness testing at the beginning of their pre-season training session. The players were then divided into their playing positions i.e. forwards (including props, second rows, hookers, flankers and number 8) and backs (including fullbacks, three-quarters, half-backs and utility backs). All participants received explanation of the current study prior to their written consent was obtained. All the risks and benefits of this current study were given to the players in detail. All procedures were approved by the institutional ethical review committee.

C. Anthropometry

The anthropometry data from the players was collected i.e. height, bodyweight and estimated maximal aerobic power (bleep test) were the test performed. The 40m acceleration test and 100m sprint test were done outdoor on the rugby pitch. The tests were performed outside on the field with the sit-ups, Push-ups, Chest press and the Back Squat were done indoors (temperature at 30 + 1.0oC and humidity at 70.0 + 5%). The players had been advised to take a rest 48 hrs prior to the testing with adequate rest and hydration.

D. Speed and Acceleration

Start speed, acceleration, and speed performance are critical factors affecting directly rugby player's performance especially the Backs (Yıldız et al., 2018). The player's acceleration was measured by the time taken to cover the 40m on the rugby pitch. Players were encouraged to go on full flight past the space marker to achieve the best times. For speed maintenance, players were asked to complete the 100m dash after resting from the 40m run. The time taken to cove the 100m was recorded as players were encouraged to run as fast as possible. The intraclass correlation coefficients for test-retest reliability were 0.95, 0.97, and 0.97, respectively, and typical errors of measurement were 1.8%, 1.3%, and 1.2%, respectively.

E. Maximal Aerobic Fitness

Depending on the level of competition, rugby union matches last 60–90 minutes averagely, with players covering 8,458– 9,929 m per match (Meir, Colla & Milligan, 2001). This shows how players require rugby union players require high levels of high levels of aerobic fitness to aid in recovery after high bouts of intensity activity (Ramsbottom, Brewer & Williams, 1988). Maximal Aerobic fitness (VO_2max) was assessed using the Multi-Stage Fitness Test (MSFT) CD (Multistage Fitness Test AA1CD; National Coaching Foundation, Leeds, UK) (Bleep Test). All participants performed the MSFT following the set procedures and protocols (Leger & Lambert, 1982) of running back and forth (i.e., Shuttle runs) along a 20m track. Participants' scores were recorded as the level and number of shuttles immediately before the beep on which they were eliminated. participants' scores (level and shuttle number) were then converted to predicted VO2 max values using the conversion table of Leger and Lambert (Leger & Lambert, 1982).

F. Maximal strength

A successful rugby player should be in a capacity to generate the high levels of muscular force to effectively tackle, lift and pull opponents during a match (Meir, Newton, Curtis, et al, 2001) consequently high levels of muscular strength and power are required to provide a fast play the ball speed and facilitate effective leg drive in tackles, scrums and rucks situations of the game. This has been examined by several studies concentrating on the strength characteristics of rugby players (Meir, Newton, Curtis, et al, 2001; O'Connor, 1996; Atkins, 2004; Baker, 2001; Baker, 2001; Baker, 2002; Baker, 2003; Baker, Nance, Moore, 2001; Warman, Humphries, Coutts, 2000; Coutts, Murphy, Dascombe, 2004). The $1RM_{BP}$ was used to test for upper extremities strength. Bench press (elbow extension, shoulder flexion, and horizontal adduction) was chosen because it seems most specific (Granados, Izquierdo, & Iba, n.d.) and the $1RM_{SQ}$ was used to measure for the lower body strength both in forwards and backs.

G. Muscular Endurance

Muscular endurance was evaluated using the 60s sit ups and push-ups method.

H. Functional Movement Screen (FMS™**)**

The Functional Movement Screen™ (FMS™) was designed to screen for the general inability to move freely, symmetrically and without pain (Cook, Burton, Hoogenboom, & Voight, 2014). It was designed as a simple tool that could be used to identify compensatory motions, imbalances or asymmetries prior to the onset of exercise(Frost, Beach, Callaghan, & Mcgill, 2013). A Deep squat (SQT) with a dowel is placed over head with the arms outstretched and the individual squats as low as possible. Each participant was given three trials on each of the seven tests (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability). Each trial was scored on a scale of 0-3 with pointers as Good depth, weak Gluteal and Falling Over as observable cues during the test.

3. Statistical procedures

Standard statistical methods were used for the calculation of the means ± standard deviation (SD). Statistical analysis was performed using SPSS v 25. One-way analysis of variance with repeated measures was used to determine the differences between tests. When a significant F value was achieved, appropriate Scheffe′ post hoc test procedures were used to locate the difference between means. The test–retest reliabilities for the experimental test demonstrated infraclass correlations of $R \geq 0.91$. Pearson product–moment correlation coefficients (r) were used to determine associations between variables. Differences in the physiological characteristics of forwards and backs for each team were compared using independent t tests and the Bonferroni adjustment. Multiple logistic regression analysis was performed to determine if any physiological variables could predict the suitability of players as forwards or backs. The level of significance was set at $p<0.05$, and data are reported as means and 95% confidence intervals (CI).

4. Results

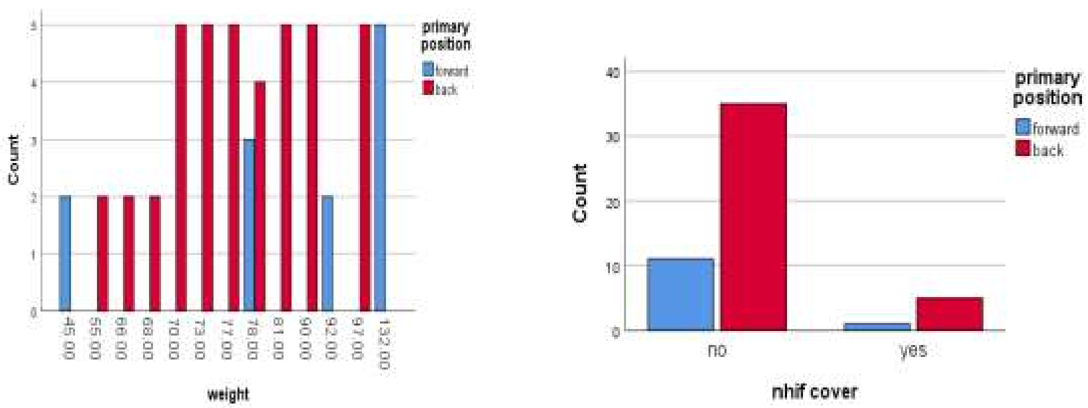
A total of 52 players were involved in the study 76.92% of the respondents were Backs while 23.08% were forwards as their primary positions. The mean age of the respondents was 22.942 ±SD 3.208 and a range of 13.

Table 1: Age Statistics

Age	
N	**52**
Mean	22.9423
Std. Error of Mean	.44486
Median	22.5000
Std. Deviation	3.20792
Std. Error of Skewness	.330
Range	13.00

The players displayed a mean weight (kgs) of 82.654± SD 20.093 with a median weight 78.00 with a range of 87.00. A cross tabulation was conducted on the weight and primary positions of the players. This displayed that majority of the heavy players were the Backs 76.92% but despite this observation majority 9.615% of the forwards were the heaviest. There was a significant correlation between the weight and primary position of the players (χ^2=42.343, df=12, P<.0001). Cross tabulation with other secondary positions did not show any significant changes in the information. Majority 88.5% (46) of the players were not covered with any insurance cover despite Rugby being a contact and a sport that has injuries only 11.5% of the players were covered with the National Hospital Insurance Fund (NHIF). Most of the backs 76.1% did not possess an NHIF cover while 83.3% of the population that had NHIF cover was constituted of Backs.

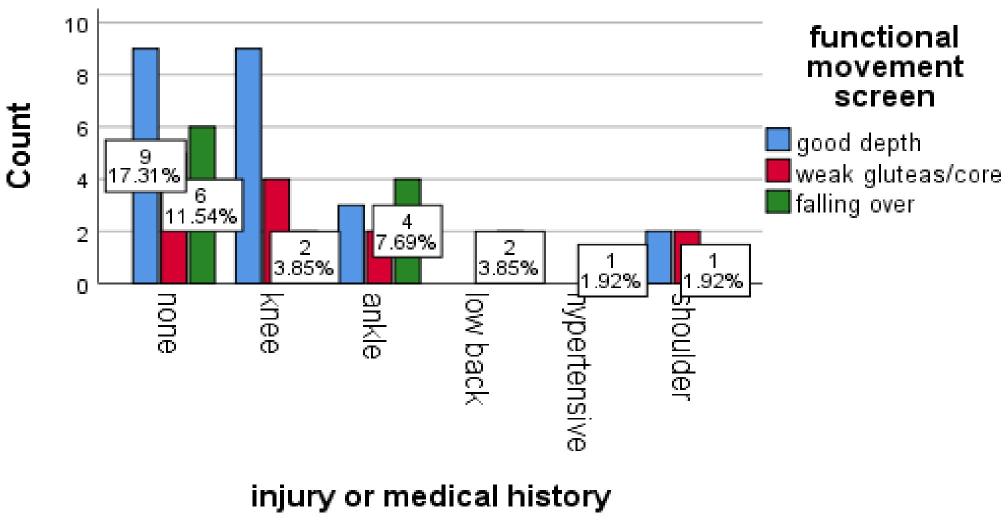
Figure 1: Crosstabulation of primary position and weight and NHIF



Majority 73.08% (38) of the respondents were students while businessmen and those employed were 13.46% respectively. The players' injury states showed that majority 38.5% did not have any injury during the study, 28.8% had a knee injury, 17.35% suffered an ankle injury, 3.8% had low back problems 9.6% had a shoulder injury while

1.9% were hypertensive. When subjected to the FMS™ 44.23% of the respondents obtained a good depth, 30.77% were falling over while 25.00% had a combination of weak gluteus/core muscles. A cross tabulation on the injury and the FMS™ indicates that there was a non-significant relationship between injury/ medical condition and FMS™ (χ^2=10.574, df=10, P<.392), although majority of the players indicated they had knee issues, majority of them were able to achieve a Good depth in FMS™.

Figure 2: Crosstabulation of Injury and FMS



The statistics were run for the bleep test multistage descriptive depicting that the minimum level attained for the players was a level 5 shuttle 5 with the maximum level attained was a level 12 shuttle 2. The mean level of the participants was a level 9 shuttle 8.

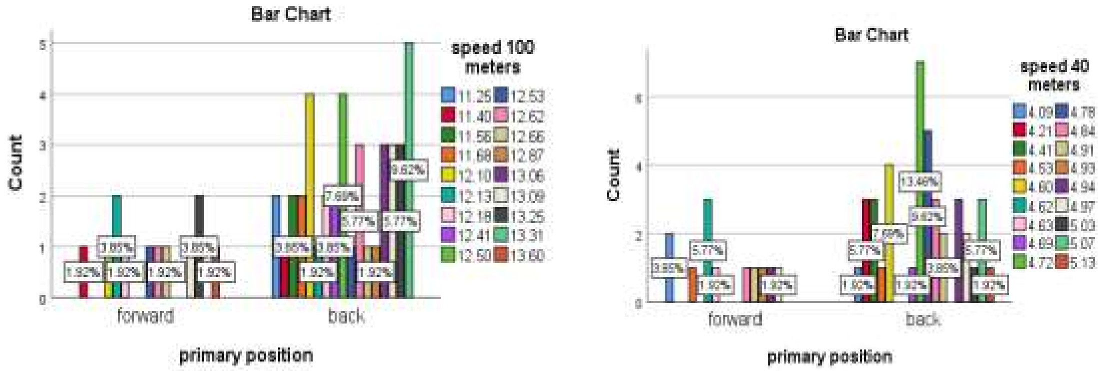
Table 2: Bleep-Test/VO2Max Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
				Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
bleep test	52	5.50	12.20	9.8715	1.87834	-.766	.330	.235	.650

The mean speed on 100m of the players was 12.533s ±SD .627 range 2.35. although the forwards displayed a slower pace compared to the backs the correlation between player's position and the speed showed that there was a non-significant relationship between the two (χ^2=16.322, df=17, P<.501).

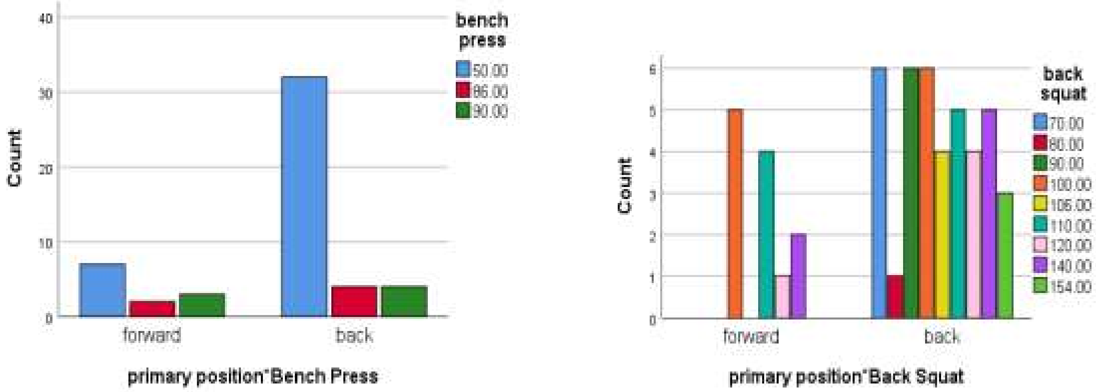
On acceleration tested on the 40m sprint the mean time (sec) achieved was 4.707±SD.268 range 1.04 median 4.720 sec. on 100m speed test, the players displayed a mean time of 12.533±SD.627 with a range of 2.35. a correlation was carried out to test out the association and correlation between the player's primary position and the 40m acceleration (χ^2=29.467, df=17, P<.030) and the 100m speed test (χ^2=16.322, df=17, P<.501).

Figure 3: Speed of the Players



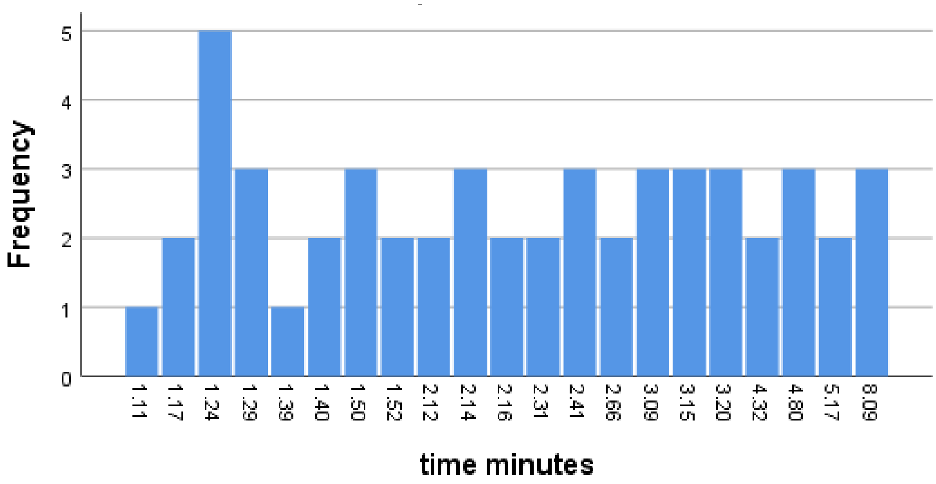
A recorded strength test was done using the bench press and squat test was conducted. A bench press means of 59.54kgs±SD16.713 with a range of 40 with the Back squat mean 107.615kgs±SD22.742 with a range of 84.0. a correlation between the primary position and the strength test was conducted with the bench press (χ^2=2.476, df=2, P<.290) and the Back squat (χ^2=11.564, df=8, P<.172). A maximal exertion push up test was also conducted yielding a mean 29.07±SD 9.376 with range of 37.

Figure 4: Bench press and Squat outcomes



A core stability test done using plank test was conducted with the timings recorded. The mean 2.757±SD1.762 with a range of 6.98, the correlation between their primary position and the planks recorded in minutes (χ^2=23.646, df=20, P<.258)

Figure 5: Planks Outcome (min)



A test of muscular endurance was done with one-minute maximum Burpees and Sit-ups. The results yielded on Burpees were a mean of 27.673±SD6.09 range 27 and on Sit up a mean 42.885±SD7.926 range 29. The correlation between primary position and sit-ups was done (χ^2=16.557, df=13, P<.220) and between primary position and push-ups (χ^2=11.564, df=8, P<.172).

A linear regression correlation was done between age of the respondents, primary position of play and Bleep test outcomes.

An *R*, .080 shows a good measure of the quality of the prediction on the dependent variable Bleep test (VO_2Max). The equation predicted a good of fit model with an Anova scores of *F* (2,49) = .156, P<.856, R^2=.006. The prediction formula yielded was a Maximal Aerobic Power:

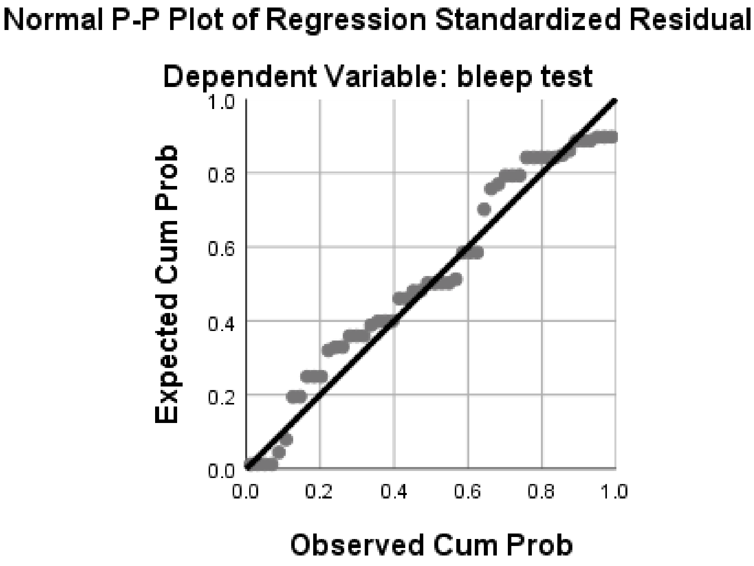
$$(VO_2Max) = 10.479 - (.350 \times Position) + (.001 \times Age)$$

Table 3: Anova outcome bleep test regression

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	1.138	2	.569	.156	.856[b]
Residual	178.798	49	3.649		
Total	179.936	51			

a. Dependent Variable: bleep test
b. Predictors: (Constant), age, primary position

Figure 6: P-P plot on Bleep test



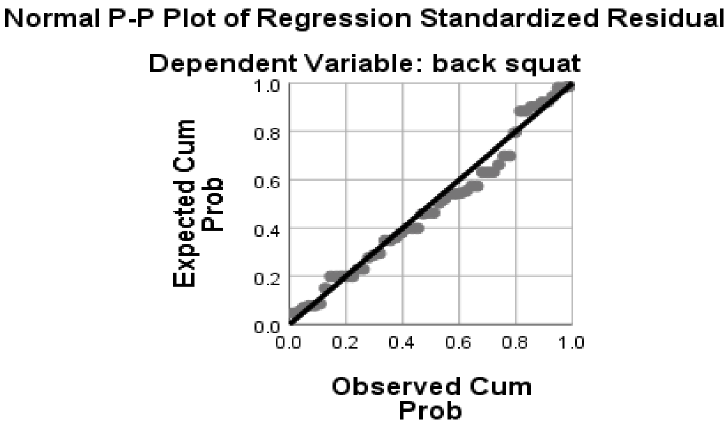
Further regression was conducted to predict back squat strength vis a vis age of the respondents and their primary position. The predicted line of good fit was *R*= .I84 and a good measure of the quality of the prediction (Back Squat strength) the values are *F* (2,49) = .873, P<.424, R^2=.034.

Table 4: Anova back squat regression outcomes

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	907.840	2	453.920	.873	.424[b]
	Residual	25468.468	49	519.765		
	Total	26376.308	51			

a. Dependent Variable: back squat
b. Predictors: (Constant), age, primary position

Figure 7: P-P plot for back squat regression



A multiple regression was carried out to investigate the equation of correlation that influence VO_2Max. The predicted *R*=.300 indicating a line of good fit with the values of

F (7,44) =.622,*P*<.735, R^2=.090. The regression prediction equation was Maximal Aerobic Power:

(VO_2Max) = 12.12 + (0.49 x Age) - (017 x Weight) – (0.657 x Position) + (257 x FMS™ (z-score) – (0.52 x 100m) + (.170 x Planks) + (0.37 x Push-ups)

Table 5: ANOVA[a] outcomes for multiple regression

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.213	7	2.316	.622	.735[b]
	Residual	163.724	44	3.721		
	Total	179.936	51			

a. Dependent Variable: bleep test
b. Predictors: (Constant), push up , weight, speed 100 meters , FMS™ , primary position , planks , age

Figure 8: Bleep test Histrogram

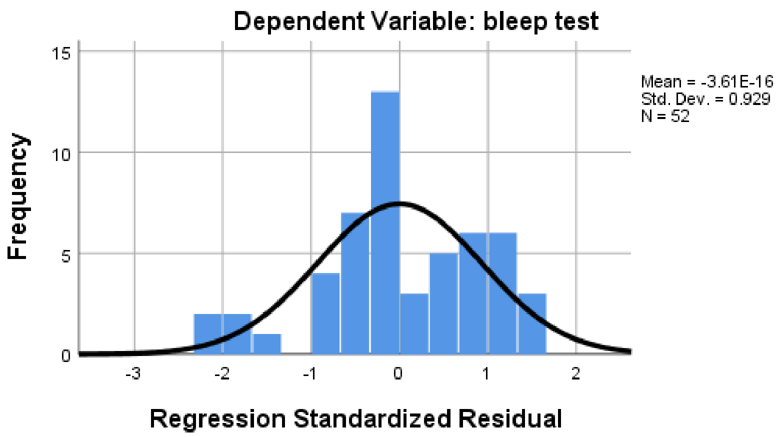
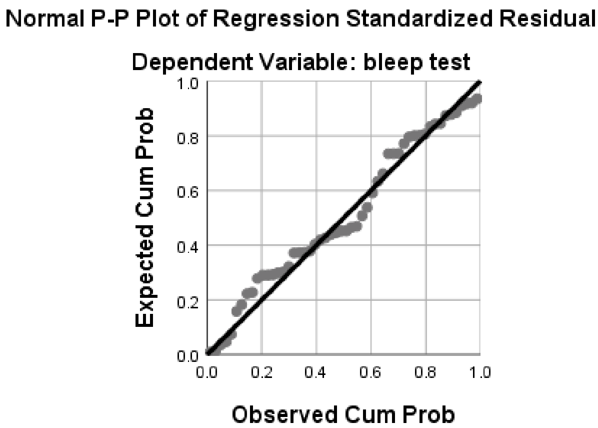


Figure 9: P-P plot of regression



5. Discussion

The total number of respondents was 52 with 76.92% of the respondents were Backs while 23.08% were forwards as their primary positions. The mean age of respondents was 22.9 yrs. ±SD3.208 this was a clear indication that most of the rugby team players were young players. The average weight of the players was 82.654Kgs± SD 20.093 with a median weight 78.00 with a and range of 87.00. backs were the heaviest with 96.15% being a bulk of them. There was a high significant correlation between the weight of the players and their primary position (χ^2=42.343, df=12, P<.0001) consequently there was a high significant correlation between the age of the players and their occupation (χ^2=40.206, df=20, P<.005) although Majority 73.08% (38) of the respondents were students while businessmen and those employed were 13.46% respectively. majority 38.5% did not have any injury during the study, 28.8% had a knee injury, 17.35% suffered an ankle injury, 3.8% had low back problems 9.6% had a shoulder injury while 1.9% were hypertensive, this indicates that injury in inherent in the sport of rugby (Maina, 2016). On the FMS™ 44.23% of the respondents obtained a good depth, 30.77% were falling over while 25.00% had a combination of weak gluteus/core muscles this indicates that the most of the players presented with muscle imbalances during the test (Dorrien, 2015). Although injuries could be a clear causation to poor scores in the FMS™ test (K Kiesel, Plisky, & Butler, 2011) results showed there was a was a non-significant relationship between injury/ medical condition and FMS™ (χ^2=10.574, df=10, P<.392). This explains the reason why despite majority of the players presented with knee issue they still managed a good depth score on the FMS™. (Kay & Blazevich, 2012)

On the maximal aerobic power VO_2Max the minimum level attained for the players was a level 5 shuttle 5 with the maximum level attained was a level 12 shuttle 2. The mean level of the participants was a level 9 shuttle 8. The Z-scores attained averaged showed that most of the players were on an average of 9.8715 depicting average fitness (Leger & Lambert, 1982). On speed maintenance 100m test the average time was 12.533s ±SD .627 range 2.35 but the forwards who are generally slower compared to the backs showed a non-significant correlation between player's position and 100m speed (χ^2=16.322, df=17, P<.501) (Yıldız et al., 2018).

Acceleration was evaluated using the 40m dash test which players presented with an average of 4.707±SD.268 range 1.04 median 4.720 sec. A correlation was carried out to test out the association and correlation between the player's primary position and the 40m acceleration which showed a significant correlation between the 40m acceleration test and the players position (χ^2=29.467, df=17, P<.030) while on the 100m speed test there was an insignificant correlation between the player's position and the 100m speed test (χ^2=16.322, df=17, P<.501) this replicates the study on rugby positions speed wise and performance (Pasin et al., 2017).

With the use of a Bench press and Back squat test, the strength tests showed a mean of 59.54kgs±SD16.713 with a range of 40 on the bench press with the Back squat mean 107.615kgs±SD22.742 with a range of 84.0 press there was a weak correlation between bench press and primary position of the player (χ^2=2.476, df=2, P<.290) (Chong et al., 2014) while the Back squat indicated a stronger correlation significant correlation (χ^2=11.564, df=8, P<.172) (Oprean et al., 2017).

The maximal exertion pus-ups yielded a mean of 29.07±SD 9.376 with range of 37 with the core stability plank test yielding a mean 2.757±SD1.762 with a range of 6.98. There was a strong correlation but a non-significant relationship between the plank test and the primary positions of the players (χ^2=23.646, df=20, P<.258) this agrees with other studies done on the same (Pasin et al., 2017; Frost et al., 2013; Kay & Blazevich, 2012). Burpees and sit-ups done yielded a mean of 27.673±SD6.09 range 27 and a mean 42.885±SD7.926 range 29 respectively. The Burpees showed a strong correlation but insignificant when (χ^2=16.557, df=13, P<.220) while the sit-ups showed a high correlation and non-significant relationship with the players' primary position (χ^2=11.564, df=8, P<.172)(Gabbett, King, & Jenkins, 2008) explained in their study the correlations between the maximal power and its influence on players position.

A linear regression showed that maximal aerobic power (VO_2Max) could be depicted with a regression formula; Maximal Aerobic Power:

(VO_2Max) = 12.12 + (0.49 x Age) - (017 x Weight) – (0.657 x Position) + (257 x FMS™ (z -score) – (0.52x100m) + (.170 x Planks) + (0.37 x Push-ups)

This was made possible through linear regression where the variables were found to depict a good line of fit with a value of F (7,44) =.622,$P<.735$, $R^2=.090$(Article, 2002).

6. Conclusions

From the study it is clear that maximal aerobic power (VO_2Max) is influenced by several factors including age of the rugby players, weight of the players and the playing positions of the players.

Muscles imbalances detected through the FMS™ is a clear predictor of injury during preseason and should be utilized to inform coaches on the Frequency, Intensity Type and Time of training to be effected through the preseason training

7. Recommendations

Future research should further clarify how preseason testing and anthropometric tests of rugby players would influence the outcome on fitness before the start of the season which the ultimate goal of most rugby players and coaches (Schneiders, Davidsson, Hörman, & Sullivan, 2011). Of keen interests to researchers is the effect of injuries on the outcome of preseason tests as a confounding and intervening variable to the achievement of optimal fitness levels in athletes without undermining factors as Age and primary player positions (Kyle Kiesel & Hall, 2007).

Declarations

Ethics approval
Ethical clearance was obtained from Masinde Muliro University of Science and Technology Ethics Committee.

Competing interest
The authors declare that they have no competing interests.

Authors & contributions
Dr. Maximilla Wanzala and Prof Edwin Wamukoya conceived, designed and performed the study. Anthony Muchiri and Micky Olutende Oloo analyzed the data. All authors read and approved the final manuscript.

Disclaimer
The findings and conclusions presented in this manuscript are those of the authors and do not necessarily reflect the official position of Masinde Muliro University.

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