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Impact of Back Strength with Selected Anthropometric Variables and Performance Tests in Indian Inter-University Cyclists

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Abstract: ***Introduction:*** ***The cyclists need appropriate muscle strength to hold on bike position and back strength plays a vital role in it.The objectives of the present study were to estimate the back strength of inter-university cyclists in Punjab, India and to search its correlation with selected anthropometric variables and performance tests studied. Materials and Methods: A total of 48 purposively selected inter-university level track cyclists (20 females and 28 males) aged 18-25 years were collected from Guru Nanak Dev University, Amritsar, Punjab, India and were considered as samples. An adequate number of controls (n= 44, 20 females and 24 males) were also taken from the same place for comparison. To serve these purposes, back strength and five anthropometric variables, viz. height, weight, body mass index (BMI), foot length, foot breadth, and three performance tests, viz. sit and reach test (S&RT), vertical jump test (VJT) and standing broad jump (SBJ)were measured in all the subjects. Results: One way analysis of variance (ANOVA) test of back strength showed significant between-group differences (p<0.001) in all the variables studied, except BMI. In female cyclists, significantly positive correlations of back strength were found with height and SBJ and significantly negative correlations with BMI and % BF. In male cyclists, significantly positive correlations of back strength were found with weight and %BF, and significantly negative correlations with BMI. Conclusion: In conclusion, it could be stated that the back strength was found to be an important contributor in the performance of the cyclists.***

Keywords: Back strength, Anthropometric variables, Performance tests, Inter-university cyclists

1. Introduction

1) Cycling is unique due to the combination of extreme postural inertia of the upper and lower body together with excessive repetitious load on the lower limbs (Brukner and Khan, 2007). For more than 20 years, scientists have examined the characteristics of successful athletes. Aspects such as body composition, strength, endurance, balance and anaerobic power are among other factors of prime importance in evaluation of athletes (Broker et al., 1999). Few sports are as varied and physiologically challenging as competitive cycling (Burke, 1981). Cycle racing is one of the few sports where performance is determined by physical output in direct interaction with a mechanical device. Consequently, anthropometric parameters need to be considered in relationship to the bicycle set-up and rider's position during competition. (McLean and Parker, 1989). Muscle strength is a major component of successful performance in almost every activity of daily living. It is vital to the maintenance of upright posture, ambulation and the accomplishment of simple tasks such as eating and dressing (Barney and Levy, 1983), also essential in various sport events.
2) Muscle strength is typically measured using dynamometry; it is based on having a person exerts maximal resistance (force) against a continuously moving (isokinetic) or an immovable (isometric) mechanical lever, using a single muscle or a muscle group. Dynamometry is highly efficient for both clinical and research purposes (Mathiowetz et al., 1984). During cycling, various positions are used to achieve proper aerodynamics to increase speed and efficiency, including lumbar spine flexion (Burnett, 2004). This prolonged flexed posture may be an important factor contributing to the development of lower back pain in cyclists as posterior active and passive spinal structures may be subjected to increased load and strain in this position (Mellion, 1994). The majority (51.5%) of cycling related injuries reported over a 4-year period were considered due to overuse. Of these overuse injuries, low back pain is the most prevalent. Fifty-eight percent of professional cyclists reported low back pain, of which 41% sought medical attention, and up to 22% of cyclists with low back pain lost time from activity. (Marsden and Schwellnus, 2010; Clarsen, 2010). As back extensor muscle activity is proportional to pedaling intensity (Usabiaga, 1997) these alterations may decrease desired performance.
3) In the present study, an attempt has been made to estimate the back strength of the inter-university cyclists in Punjab, India and to search its correlation with selected anthropometric variables and performance tests.

2. Materials and Methods

1) Participants

A total of 48 purposively selected inter-university level track cyclists (20 females and 28 males) aged 18-25 years were collected from Guru Nanak Dev University, Amritsar, Punjab, India. An adequate number of controls (n= 44, 20 females and 24 males) were also taken from the same place for comparison. The age of the subjects was estimated from the date of birth obtained from their respective institutes. A written consent was obtained from the subjects. The data were collected under natural environmental conditions in morning (between 8 AM. to 12 noon). The study was approved by the institutional ethical committee.

2) Back Strength Measurement

The back strength was measured using back-leg-chest dynamometer (BLC Dynamometer, Baseline, New York, USA) . The subject was positioned with body erect and knees bent so that grasped-hand rests at proper height. Then straightening the knees and lifting the chain of the dynamometer, pulling force was applied on the handle. The body was inclined forward at an angle of 60 degrees. The strength of the back muscles was recorded on the dial of the dynamometer as the best of three trials in kg. All subjects were tested after 3 minutes of independent warm-up. Thirty seconds time interval was maintained between each back-strength testing.

3) Anthropometric Measurements

Anthropometric variables of the subjects were measured using the techniques provided by Lohmann et al. (1988) and were measured in triplicate with the median value used as the criterion. Subjects were weighed in minimal light-weight clothing, bare foot, using standard weighing machine. Stadiometer (Holtain Ltd. Crymych, Dyfed, UK) was used for measuring standing height. Subjects were asked to stand bare foot on horizontal surface. Heel touched the ground, counter board of stadiometer was brought down till it touches the vertex. The height of subjects was recorded in cm. The weight was measured by digital standing scales (Model DS-410, Seiko, Tokyo, Japan) to the nearest 0.1 kg. Body mass index (BMI) was calculated from height and weight as follows: BMI=weight (kg) / height^2 (m^2). Foot length and foot breadth were measured using sliding calliper in cm. Percent body fat was calculated with the following formula (Durnin and Womersley, 1974):

Per-cent body fat = Females (17-68 years)
= (1.37 × BMI – 3.47)
Males (17-76 years)
= (1.34 × BMI – 12.47)

4) Sit and Reach Test

It is used to estimate the back and hamstring flexibility. The subject was asked to warm up for 10 minutes and then remove their shoes. The examiner secured the ruler to the box top with the tape so that the front edge of the box lines up with the zero mark on the ruler and the zero end of the ruler points towards the athlete. The subject sat on the floor with their legs fully extended with the bottom of their bare feet against the box. The subject placed one hand on top of the other, slowly bended forward and reached along the top of the ruler as far as possible and was asked to hold the stretch for two seconds. The examiner recorded the distance reached by the subject finger tips. The subject performed the test three times. The examiner calculated and recorded the average of the three distances and used this value to assess subject's performance.

5) Vertical Jump Test

It is used to measure the explosive power of the legs. This test involved measuring the difference between standing reach and the height reached at the peak of a vertical jump. The jumping technique was reviewed. Warm-up with several easy jumps preceded with a few minutes rest. While resting, the subject stood with side and reached up as high as possible keeping the feet flat on the ground. The standing reach was recorded and marked. Standing slightly away from the wall or under vertical jump flag, the subject jumped up as high as possible using momentum of both arms and legs to assist in projecting the body upwards finally to touch the wall at the highest point of the jump. Multiple attempts with short rests were performed (usually 3 attempts). The "net height" was calculated by subtracting the standing reach height from the jump height in cm best of three score was recorded.

6) Standing Broad Jump (Standing Long Jump)

It is a common and easy to administer test of explosive leg power. Instrument used was steel tape. The subject stood behind a line marked on the ground with feet slightly apart. A two foot take-off and landing was instructed with swinging of the arms and bending of the knees to provide forward drive. The subject attempted to jump as far as possible, landing on both feet without falling backwards. Best of longest distance score was recorded in cm. Three attempts were allowed.

7) Statistical Analysis

Descriptive statistics (mean ± standard deviation) were determined for the directly measured variables as well as the derived one. One way analysis of variance was tested for the comparisons of data among the male and female cyclists and controls, followed by post-hoc Bonferroni test. Correlation coefficients of back strength with other variables were done using SPSS (Statistical Package for Social Science) version 20.0. A 5% level of probability was used to indicate statistical significance.

3. Results

1) Table 1 showed one way analysis of variance (ANOVA) test of back strength, selected anthropometric variables and performance tests in cyclists and controls. Significant between-group differences ($p<0.001$) were found in all the variables studied, except BMI among these four sets of data. Female cyclists have higher mean values in height (172.1 cm), foot length (26.80 cm), foot breadth (8.9 cm), back strength (65 kg), sit and reach test (52 cm), vertical jump test (34 cm) and standing broad jump (201 cm), and lesser mean values in weight (74 kg), body mass index (21.68 kg/m^2), percent body fat (26.28%) than their control counterparts (165.6 cm, 25 cm, 8.1 cm, 25 kg, 45 cm, 32.5 cm and 156 cm respectively). Male cyclists have higher mean values in foot breadth (9.60 cm), back strength (183 kg), sit and reach test (53.50 cm), vertical jump (50 cm), standing broad jump (280 cm), and lesser mean values in height (184.2 cm), weight (110 kg), foot length (29.5 cm), body mass index (23.39 kg/m^2), percent body fat (18.94%) than their control counterparts (9.0 cm, 121 kg, 47 cm ,46 cm and 245.5 cm respectively).

2) Table 2 showed correlation matrix of back strength, selected anthropometric variables and performance tests in cyclists. In female cyclists, significantly positive correlations of back strength were found in height ($r= 0.51$) and SBJ ($r=0.78$) and significantly negative correlations were found with BMI ($r= -0.64$) and % BF ($r= -0.65$). In male cyclists,

significantly positive correlations of back strength were found with weight (r=0.49) and %BF (r=0.41) and significantly negative correlations were found with BMI (r=-0.41).

Table 1: One way analysis of variance of back strength, selected anthropometric variables and performance tests in cyclists and controls

Variables	FC (n=20) Mean SD		MC (n=28) Mean SD		CF (n=20) Mean SD		CM (n=24) Mean SD		F- value	p-value
Height	161.78	5.02	171.00	5.37	156.22	4.28	171.74	7.15	39.616	0.001
Weight	57.50	6.48	69.64	8.44	57.87	9.62	71.37	13.29	12.457	0.001
Body Mass Index	21.68	2.97	23.39	3.14	23.25	3.93	23.70	3.83	1.424	0.241
Foot Length	25.04	1.05	25.82	1.54	23.22	0.99	25.77	1.39	18.919	0.001
Foot Breadth	7.83	0.37	8.54	0.48	7.42	0.35	8.27	0.41	33.275	0.001
% Body Fat	26.28	4.14	18.94	4.21	28.45	5.39	19.36	5.12	23.608	0.001
Back Strength	36.85	16.42	99.89	30.36	9.25	7.21	70.45	25.18	70.448	0.001
S it & Reach Test	44.00	5.46	45.62	5.94	37.35	5.85	36.20	6.18	15.364	0.001
Vertical Jump Test	26.20	4.03	40.19	6.28	21.19	4.05	33.50	6.93	48.559	0.001
Standing Broad Jump	172.05	14.27	250.26	17.35	128.35	16.24	202.83	26.40	165.437	0.001

Table 2: Correlation matrix of back strength, selected anthropometric variables and performance tests in cyclists

Variables	HT	WT	BMI	FL	FB	%BF	S&RT	VJT	SBJ	BS
HT	1	-0.77	**-0.56***	0.58	0.35	**-0.55***	-0.04	0.02	0.35	**0.51***
WT	0.20	1	0.86	0.07	0.05	**0.87****	-0.11	-0.18	-0.38	-0.46
BMI	-0.34	**0.85****	1	-0.23	-0.10	**1.00****	0.08	-0.19	**-0.51***	**-0.64***
FL	**0.56***	0.17	-0.14	1	0.41	-0.22	-0.11	0.09	-0.14	0.16
FB	**0.54***	0.26	-0.08	0.18	1	0.09	0.02	-0.30	-0.01	0.25
% BF	-0.34	**0.85****	**1.00****	-0.14	-0.08	1	-0.10	-0.21	**-0.53***	**-0.65***
S&RT	-0.27	0.08	0.20	-0.22	-0.20	0.20	1	0.10	0.08	0.27
VJT	0.01	0.01	0.03	-0.12	-0.20	0.03	0.21	1	0.25	0.24
SBJ	0.23	**-0.57***	**-0.64****	-0.09	0.04	**-0.64****	0.04	0.48	1	**0.78****
BS	0.13	**0.49***	**-0.41***	0.04	0.19	**0.41***	0.26	0.12	0.09	1

HT = height, WT = weight, BMI = body mass index, FL = foot length, FB = foot breadth, %BF = percent body fat, S&RT = sit and reach test, VJT = vertical jump test, SBJ = standing broad jump, and BS = back strength.

4. Discussion

1) During cycling, various positions are used to achieve proper aerodynamics to increase speed and efficiency, including lumbar spine flexion (Burnett, 2004). This prolonged flexed posture may be an important factor contributing to the development of lower back pain in cyclists as posterior active and passive spinal structures may be subjected to increased load and strain in this position (Mellion, 1994). A flexed spinal position commonly adopted by cyclists inverts the physiologic intervertebral angle, changing the area of spinal loading. (Usabiaga, 1997). Also, the reach distance is defined as the measurement from the centre of the seat tube/post to the transverse position of the middle of the handle bars. (Burke, 2002) It has been suggested that low back pain in cyclists may be related to an incorrect reach distance (Mellion, 1991, 1994). In the seated position during cycling the optimal position is one of hip flexion, anterior pelvic tilt and a reduced spinal flexion, this position would minimise wind resistance (Burke, 2002; Usabiaga,1997; Kyle,1994; Heil,1997) and this could improve cycling speed (Kyle,1994) and may also reduce the risk of spinal injury. However, very few cyclists, often only elite cyclists, maintain this ideal position. Most cyclists maintain a position in which there is a varying degree of spinal flexion, as well as varying angles of anterior and posterior pelvic tilt (Bressel, 2003; Salai, 1999).

2) Maximal strength training improves cycling economy in competitive cyclists (Sunde, 2010). In a cross-sectional study of cyclists with similar maximal oxygen consumption and peak aerobic power output demonstrated lowered electromyography activity during the pedal stroke in the cyclists with higher maximal strength (Bieuzen et al., 2007). In the present study, male cyclists have significantly higher mean values for back strength than controls as well as female cyclists, whereas female cyclists have significantly higher mean values for this trait as compared to control females. Gender predicted 62% of back leg chest strength, whereas the strength variables explained a significant proportion of 87% of the variance (Gill et al., 2016).The differences in back strength between the two sexes of cyclists were might be due to physical, physiological and training programs. In the present study back strength was found to have significant positive correlation with height, weight, vertical jump test and standing broad jump and negative correlation with percent body fat and body mass index. According to Bamman et al. (2000), anthropometric variables are directly related to muscle. In a similar study done by Sharma et al. (2017a) on Indian field hockey players, back strength was found to be more for the taller players having longer trunk and hand, and with broader chest. It was also more among the players who were heavier, leaner and having bulkier arms. Another study done by Sharma et al. (2017b) on hockey players and cyclists, found back strength to having major influence on vertical jump. The physique of an athlete is considered to be an important determinant of success and in top level sport there would appear to be a tendency for individuals to gravitate towards the event to which they are anthropometrically best suited

(Garay, 1974; Housh, 1966; Tanner, 1964). In the present study strong association was reported between back strength of the cyclists and the selected anthropometric and performance variables.

3) In order to help cyclists and their optimum posture, reliable anthropometric measuring is of utmost importance. (Mestdagh, 1997). In the present study, male cyclists were longer and heavier than female cyclists and female controls but shorter and lighter as compared to their control counter parts. In the past study of Craig and Norton (2004), elite track cyclists possessed key physical and physiological attributes which were matched to the specific requirements of their events: these cyclists must have the appropriate genetic predisposition which was then maximised through effective training interventions. According to Burke et al. (1980), cyclists were said to be taller and heavier than distance runners, ice hockey players and speed skaters. The mean height and weight of 40 male road cyclists studied at the 1969 world championship was 175 cm and 70 kg respectively. Since foot length is relevant to saddle height, accurate determination of the position of the cleats on the cycling shoes is important, the more so as the ball of foot must be positioned directly above the pedal spindle so that the use of the lever formed by midfoot and hindfoot can be optimised (Mestdagh, 1997). Analysis of foot length revealed the sprinters to have significantly ($P < 0.01$) shorter feet than any of the other groups, whilst the time trialists had the longest feet. Indeed, the significantly shorter bone lengths of the sprinters would appear to support the comments of Astrand and Rodahl (1986) who suggested that athletes with shorter limbs could tolerate a greater quickness of movement.

4) However, female cyclists were leaner and longer than control females but not to the male cyclists. It may be due to genetic predisposition and growth affected by sports activity or may be accounted for their intense physical training for years and due to selection criteria for their specific sport. Females were known to have more fat deposition around thighs apart from buttocks and hips as compared to males (Fragala, 2012). Similar findings were found in this study where females had higher mean values for hip circumference and percent body fat compared to their male counterparts.

5) In the present study, male and female cyclists have lower mean values of % body fat and BMI as compared to controls. This might be due to continuous involvement in high physical work demand by their sport. Through training regimen, cyclists had achieved a superior body composition, aerobic work capacity and anaerobic work capacity (Tsunawake et al., 1993). Athletes with a low fat mass had an enhanced speed in the race, because they were carrying less weight (Knechtle et al., 2009). With respect to track cycling, increased non-functional mass has a triple effect of decreasing performance since it increases the energy cost of acceleration, rolling resistance and the projected frontal surface area of the cyclist. (Gregor, 2000).

6) In the present study, male cyclists have higher mean values in all performance test (i.e. sit and reach test, vertical jump test and standing broad jump) to female cyclists and control group. Female cyclists have greater flexibility and higher leg explosive power compared to their counterpart. Sit and reach test was found to have higher mean values in cyclists as compared to their control counterparts. It has been suggested that a forward or anterior pelvic tilt (APT) of the cyclist's pelvis is favourable for cycling as it may reduce the tensile forces on the lumbo-sacral spine, thereby reducing the risk of low back pain in cyclists. High hamstring extensibility was associated to lower thoracic angles and more anterior pelvic tilt. (Muyor, 2011). Sit and reach test showed no significant correlations with back strength. Similar findings were found by Koley et al. (2012) when they found no significant correlations of back strength with flexibility measures in Indian inter-university hockey players. Vertical jump test was found to have higher mean values in cyclists as compared to controls. Vertical jump testis a good measure of strength, explosive power and muscle fibre composition (Bosco et al., 1983) of lower limb joint musculatures, mainly of ankle, knee and hip joints (Ostojic et al., 2010). In the present study, vertical jump test was found having significant positive correlations with back strength, weight, height, standing broad jump, foot breadth and significant negative correlations with percent body fat. Similar type of study done by Sharma et al. (2017a) concluded that vertical jump correlated significantly and positively with weight, height, trochanterion height and back strength. According to Butcher et al. (2007), the erector spinae is one of the muscles enabling spine extension and an increase in the overall mechanical work. Therefore, the erector spinae may be considered as a trunk extensor muscle just as the gluteus is a hip extensor muscle. From this viewpoint, the increase in vertical jump height after trunk muscle strengthening, hence supporting the present study having correlations of vertical jump height with back strength. Standing broad jump was found to have higher mean values in cyclists as compared to their control counterparts. According to (Castro-Pinero, 2009), standing broad jump is a valid test to assess lower body muscular strength and upper body muscular strength in youth. In the present study, it was also found to have significant positive correlations with back strength, weight, height, foot breadth, vertical jump test and significant negative correlations with percent body fat. Standing broad Jump test is very technical and depends on anthropometric, mechanics, and coordinative factors (Aguado et al, 1997; Pandy, 1991). It is argued that the high levels of technique that required the standing broad jump, and the influence of anthropometric factors, such as height and weight, could be of greater importance to the outcome than the lower body explosive muscular strength attained by the participant (Young, 1995; Aguado, 1997). Several studies found a significant correlation between the standing broad jump and the vertical jump test (Garc´ıa-Lo´ pez, 2005; Markovic, 2004), whereas others did not (Aguado, 1997). Milliken et al. (2008) reported a weaker association between the standing broad jump and the vertical jump test in children aged 7–12 years.

5. Conclusion

It could be concluded that the back strength was positively correlated with performance tests namely the vertical jump test and standing broad jump and non-modifiable anthropometric variables like height and modifiable anthropometric variables like weight, whereas negative correlations were found with percent body fat in female players and positively in male players. Hence, it could be stated that the back strength was found to be an important contributor in the performance of the cyclists. Thus, the finding may be helpful for training program development, talent identification and selection of players for inter-university cyclists. The present study may also inspire for further large scale studies in the related field.

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