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Cardiovascular Fitness as a Developmental Predictor of Quality of Life in Adolescent Football Players

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Abstract:

- ***Background:***

Adolescence is a critical period that has high physical growth rates and psychosocial development rates. In the case of young athletes, the transition between normal developmental processes and sport-related requirements is particularly challenging, but the developmental patterns that connect physical and perceived wellbeing are not studied sufficiently.

- ***Objectives:***

The purpose of the study was to: (1) analyse age effects on anthropometric markers, cardiovascular fitness, and quality of life in adolescent football players(12-16yrs); (2) test physical variables in relation to areas of quality of life; (3) establish the predictive validity of a developmentally sound outcome of wellbeing.

- ***Methods:***

A cross-sectional study involving 455 male footballers between the ages of 12-16 years (12-13y, n=67, 13-14y, n=128, 14-15y, n=148 and 15-16y, n=112) of North Bengal, India. Measurements were standardized (height, weight, BMI, Harvard Step Test (cardiovascular fitness) and the WHOQOL-BREF (measuring Physical, Psychological, Social, and Environmental QoL domains). The statistical tests consisted of descriptive statistics, ANOVA post hoc tests, correlation test, multiple regression, moderation test, structural equation modelling and cluster test.

- ***Results:***

There were great developmental trends. Height was significantly increasing with age up to 16 ($F=44.1$, $p<.001$, $\eta^2=.23$) and BMI was decreasing ($F=21.3$, $p<.001$, $\eta^2=.12$). There was an improvement in cardiovascular fitness ($F=17.8$, $p<.001$, $\eta^2=.11$) with age. QoL domains represented U-shaped curves with a substantial decline in these ages 14-15, then an incomplete recovery. HST showed positive correlations with all QoL domains (Physical: $r=.40$; Psychological: $r=.38$; Social: $r=.32$; Environmental: $r=.29$; all $p<.001$) and was the sole significant predictor in all regression models that accounted 9-16% of the variance. SEM indicated that physical and psychological mediation between fitness and social wellbeing are present (indirect effect=.13, $p<.001$). The age of the respondents reduced the fitness-social QoL relationship (moderation $p=.02$).

➢ ***Conclusion:***

Cardiovascular fitness, as opposed to anthropometric measures, is found to be a developmentally strong predictor of quality of life among adolescent footballers. The QoL dip in the mid-adolescent 14-15 years despite the rising fitness is a sign of a critical period of interventions through physical-psychosocial programs in youth sports activities.

Keywords: *Adolescent Athletes, Quality of Life, Cardiovascular Fitness, WHOQOL-BREF, Wellbeing, Youth Football.*

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I. INTRODUCTION

Adolescence is a very sensitive stage of development, which is characterized by extreme physical, cognitive, emotional and social transformations (Backes et al., 2019; Mastorci et al., 2024; Sawyer et al., 2018). An additional complication is also a need to adapt to sport specific physiological needs, exercise programs and competition demands in the scenario of the estimated 300 million young sportsmen in the world (Bergeron et al., 2015; Nikolaidis & Son'kin, 2023; Sabato et al., 2016). The relationship between physical growth and the psychosocial wellbeing of the athletic youth groups is therefore significant in the determination of holistic health and improvement of the performance of sports participation (Sinha, 2024).

Measurement of height, weight, and body mass index (BMI) is another anthropometric measurement, which is one of the foundations of growth monitoring and nutritional assessment in teens (Cole et al., 2000; de Onis et al., 2007). Likewise, cardiovascular fitness tests including the Harvard Step Test (HST) are useful in terms of physical conditioning and health status(Brouha et al., 1943; McArdle et al., 2015). Nevertheless, these objective physical measures and perceived wellbeing have not been sufficiently defined, especially at various stages of developmental adolescence that can be characterized as Health-Related Quality of Life (HRQoL) (Ravens-Sieberer et al., 2014).

By Quality of Life, the World Health Organization comprises the perceptions of individuals on where they are in life, relative to their culture and value systems, to their goals, expectations, standards and concerns (WHOQOL, 1995). To adolescent athletes, the domains of QoL are not restricted to physical health, but that of psychological wellbeing, social connections, and environmental settings all of which can be impacted by sports involvement and physical growth in their own unique ways (WHOQOL, 1995; Eime et al., 2013; Moeijes et al., 2019).

The available literature has contradictory views. There is a study that supports the presence of positive relationships between physical fitness and different domains of QoL in adolescent youth (Biddle & Asare, 2011a; Ortega et al., 2008). and studies that support the impact of body image perceptions on psychological wellbeing over actual anthropometry (Griffiths et al., 2010; Mond et al., 2011). Also, the majority of studies have been conducted on Western populations or clinical samples, and little information is available concerning community-based athletic youth in South Asian settings (Patton et al., 2016). The ways in which these relationships vary over the adolescent years, or developmental trajectories, have not been studied in particular.

The given study attempts to fill this gap, by exploring the school attending footballers of four age groups (12-16 years) in North Bengal, India. Football is among the most widespread youth sports in the world that provides a suitable background to investigate physical-psychosocial relations. The targeted objectives were:

- ➢ To compare the patterns of development in the anthropometric (height, weight, BMI), cardiovascular fitness (Harvard Step Test) and the domains of the quality of life among four age groups of adolescent football players.
- ➢ To examine the bivariate and multivariate correlation of cardiovascular fitness and QoL domains.
- ➢ To find out what physical attributes (age, height, weight) best predict QoL across different developmental stages of adolescence.
- ➢ To identify the relationships between anthropometric, cardiovascular fitness and HRQoL domains.
- ➢ To investigate the possible mediation paths and developmental moderation.

II. METHODS

➢ *Study Design and Participants*

The study was a descriptive cross-sectional study that was done June, 2024 to August, 2025. Purposive sampling was done in football programs in schools of North Bengal in India, where a total of 455 adolescent male footballers were recruited. Inclusion criteria were: (1) age 12-16 years, (2) active football team training at school at least 6 months, (3) no acute illness or injury at the time of assessment and (4) informed assent with parental consent. All the participants were separated into four age groups according to the development stages: Group A (12-13 years, n=67), Group B (13-14 years, n=128), Group C (14-15 years, n=148), and Group D (15-16 years, n=112).

➢ *Ethical Considerations*

The research conformed to the general principles of ethics concerning educational research on human subjects. Data collection was preceded by approval of the Departmental Research Committee of the institution of the authors. It was voluntary, with parents/guardians informed

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consent and adolescents assent. The responses were anonymous and confidential, and no personal data was taken.

- *Inclusion Criteria*

- ✓ Participants Male adolescents between the age of 12 to 16 years
- ✓ Engaging actively in school-based football training.
- ✓ At least 3 months of continuous training.
- ✓ WHOQOL-BREF assessment tools.
- ✓ Denies any acute disease or injury at the time of assessment.
- ✓ Located at North Bengal, India.
- ✓ Written consent with parental approval.

- *Exclusion Criteria*

- ✓ Age Outside Range: <12 or >16 years
- ✓ Non-Football Athletes
- ✓ Less than 3 months of football training experience
- ✓ Existence of acute injury, disease or any condition that is also contraindicated by physical activity.
- ✓ Chronic Health Disorders: Recognized cardiovascular, respiratory, neurological, or metabolic conditions that might influence the performance of fitness.
- ✓ Lack of consent of the participants or their parents.
- ✓ Irregular attendance at school or dropping out at the time of assessment.

➢ *Measures and Procedures*

- *Anthropometric Measurements*

Measurements were done in the morning and followed standard protocols by researchers who had been trained.

✓ *Height:*

The height was measured to the nearest 0.1 cm with a portable stadiometer (Seca 213, Germany) with the participants in the Frankfurt plane and barefoot.

✓ *Weight:*

Weighing the participants to the nearest 0.1 kg (using calibrated digital scale, Tanita HD-351, Japan) in light athletic attire.

✓ *Body Mass Index (BMI):*

It is calculated as weight (kg)/height (m^2). The participants were categorised on the basis of WHO age- and sex-specific BMI percentile, including underweight (less than the 5^{th} percentile), normal (5^{th} - 85^{th} percentile), overweight (85^{th} - 95^{th} percentile) and obese (above the 95^{th} percentile).

- *Cardiovascular Fitness Assessment*

The cardiovascular fitness was measured with the help of Harvard Step Test (Brouha et al., 1943), a submaximal exercise test which is valid in the field. The participants were asked to stand up and down on a 20 Inches (50.8 cm) bench at the pace of 30 steps per minute (metronome guided) in 5 minutes or volitional exhaustion. Immediately after stopping, sit down and heart rate count was recorded during three 30-second intervals: at 1 to 1.5 minutes after the exercise. It is necessary only when the short version of the test is used. In case the long form of the test is conducted, there was an extra heart rate measures between 2 to 2.5 minutes and between 3 to 3.5 minutes. For this study to determine the Fitness Index (long form) the formula was done as follows:

$$\text{Fitness Index (short form)} = \frac{(100 \text{ x test duration in seconds})}{(5.5 \text{ x pulse count between 1 to 1.5 minutes})}$$

$$\text{Fitness Index (long form)} = \frac{(100 \text{ x test duration in seconds})}{(2 \text{ x sum of heart beats in the recovery periods})}$$

The greater the scores, the better is the cardiovascular fitness (Fox et al., 1973). The test-retest reliability in our sample was r=.89 (p<.001).

- *Quality of Life Assessment*

Quality of Life was measured with the WHOQOL-BREF instrument (Skevington et al., 2004; WHOQOL-BREF, 1998) which is a validated 26-item questionnaire with a score relative to four domains (see Figure 1):

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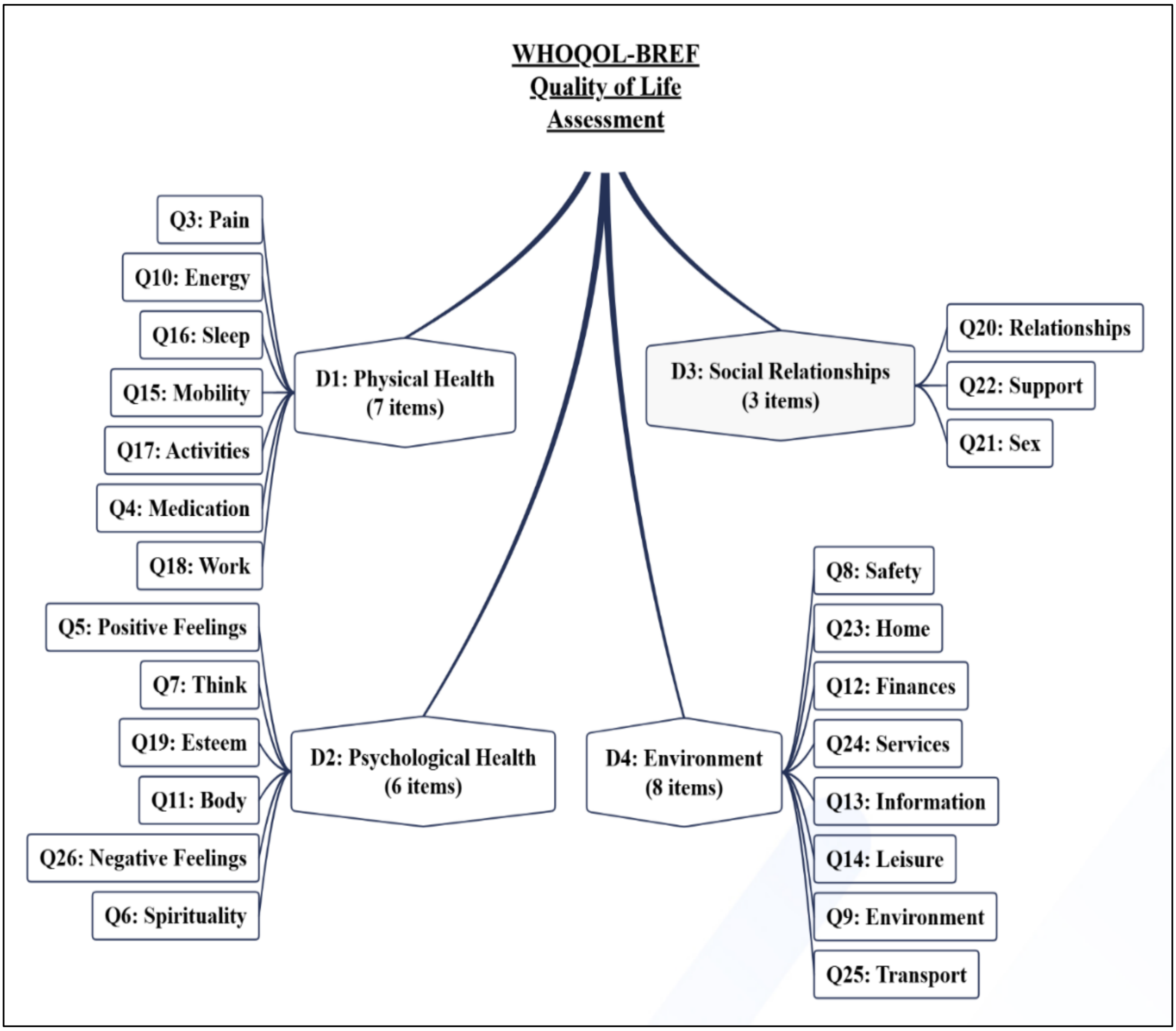

Fig 1 The 4 Pillars of Quality of Life: WHOQOL – BREF Framework

- ✓ Physical Health (7 items): Pain, energy, sleep, mobility, activities, medication, work and capacity.
- ✓ Psychological Health (6 items): Meaning, body image, negative feelings, Positive feelings, self-esteem, and concentration.
- ✓ Social Relationships (3 items): Relationships, support and sex life.
- ✓ Environment (8 items): Safety, home, finances, services, information, leisure, environment and transportation.

The rating is done on a 5-point Likert scale. The domain scores were coded into a score of 0 to 100 based on the manual with the higher the score, the higher the QoL. The WHOQOL-BREF has been found to possess satisfactory psychometric attributes across cultures (Saxena et al., 2001) and respectable internal consistency in our sample (Cronbachs alpha Physical=.78, Psychological=.81, Social=.72, Environment=.79).

➤ *Statistical Analysis*

IBM SPSS statistics (Version 27.0) and Mplus (Version 8.4) were used to analyze data. The significance was determined to be 2 =.05 (two-tailed).

- Descriptive Statistics: Means, Standard deviations, ranges and frequency distributions have been determined on all the variables.
- Group Comparisons: One-way Analysis of Variance (ANOVA) with Tukey HSD post-hoc tests compared the results across the age groups. It was indicated that the effect sizes were calculated with the use of partial eta-squared (η 2), which was described as small (.01), medium (.06), and large (.14) (Cohen, 1988; Richardson, 2011).
- Correlational Analysis: Pearson correlation coefficients were used to test the bivariate relationships. Several comparisons in total were corrected using Bonferroni.
- Multiple Regression Analysis: There were four standard multiple regression models that were tested to predictors

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of each QoL domain and the independent variables were comprised of age, height, weight, BMI and HST. The assumptions of linearity, homoscedasticity, normality of the residual values and the lack of multicollinearity (VIF<5) were satisfied.

- Moderation Analysis: Correlations between HST-QoL and age group were tested by hierarchical regression to establish the moderating role of age group. Main effects were followed by addition of interaction terms (HST × Age Group dummy variables).
- Structural Equation Modelling (SEM): Maximum likelihood estimation tested mediation pathways. Model fit was evaluated using χ^2/df ratio (<3), CFI (>.95), RMSEA (<.08), and SRMR (<.08) (Hu & Bentler, 1999).
- Cluster Analysis: Clustering was used to find the profiles of the athletes by BMI and HST. Silhouette coefficients and interpretability were used to determine the optimum number of clusters.
- Power Analysis: G*Power post-hoc showed power greater than .99 at f = .25 in ANOVA with N = 455.

III. RESULTS

➤ *Sample Characteristics and Developmental Trends*

The Descriptive statistics of the total sample (N=455) are shown in Table 1. The mean age of the participants was 14.13 years old with a standard deviation of 1.06. The mean BMI was 17.21 +/-1.48 kg /m 2, 79.3% were normal weight, 14.5% underweight, 5.7% overweight and 0.4% obese. Mean HST score was 53.06 / 4.08, which was moderately cardiovascular fitness.

Table 1 Descriptive Statistics for Total Sample (N=455)

Variable	Mean ± SD	Range	Skewness	Kurtosis
Age (months)	169.5 ± 12.7	144-192	0.32	-1.02
Height (cm)	162.0 ± 7.4	144-181	0.18	-0.45
Weight (kg)	45.1 ± 4.0	28-57	0.22	0.36
BMI (kg/m²)	17.21 ± 1.48	13.51-21.33	0.41	0.58
HST Score	53.06 ± 4.08	43.35-73.96	0.68	1.22
QoL- D1 Physical	51.38 ± 11.52	10.71-75.00	-0.42	0.21
QoL- D2 Psychological	63.42 ± 13.91	20.83-95.83	-0.38	0.15
QoL- D3 Social	64.49 ± 17.32	0.00-100.00	-0.56	0.48
QoL- D4 Environment	58.97 ± 14.08	25.00-87.50	-0.21	-0.32

Table 2 indicates the pattern of development of the four age groups. The ANOVA (one-way) showed significant differences in all variables (all p<.01). There was progressive linear growth in height (η^2=.23, large effect) with Group D tallest (166.1 ±7.8 cm). Weight was moderately increased (η^2=.02, small effect), and Group D was heaviest (46.1 4.1 kg). The trend in BMI showed a counterintuitive negative age effect (η^2= +.12, medium effect), Group A showing the highest values in BMI (17.94 + 1.24) and Group D presenting the lowest values (16.70 + 1.41). The scores in HST increased with age (η^2=.11, medium effect), and the best fitness was recorded in the Group D (54.67 +3.88).

Table 2 Developmental Trends Across Four Age Groups (ANOVA Results)

Variable	Group A 12-13y (n=67)	Group B 13-14y (n=128)	Group C 14-15y (n=148)	Group D 15-16y (n=112)	F (3,451)	p-value	η²	Post-hoc (Tukey HSD)
Age (months)	152.6 ± 2.9	159.9 ± 4.9	174.1 ± 3.6	186.8 ± 2.8	2274.1	<.001	0.94	D>C>B>A
Height (cm)	157.6 ± 4.9	159.8 ± 5.9	162.7 ± 5.9	166.1 ± 7.8	44.1	<.001	0.23	D>C>B>A
Weight (kg)	44.7 ± 3.7	44.7 ± 4.3	44.9 ± 3.9	46.1 ± 4.1	3.6	0.013	0.02	D>A, B; D>C
BMI (kg/m²)	17.94 ± 1.24	17.57 ± 1.50	16.99 ± 1.39	16.70 ± 1.41	21.3	<.001	0.12	A, B>C, D
HST Score	51.00 ± 3.64	52.92 ± 5.01	52.76 ± 3.55	54.67 ± 3.88	17.8	<.001	0.11	D>A, B, C; B, C>A
QoL-Physical	54.10 ± 10.32	51.46 ± 13.15	49.31 ± 11.14	52.88 ± 9.94	4.1	0.007	0.03	A>C; D>C
QoL-Psychology	67.88 ± 11.20	63.55 ± 15.22	61.59 ± 15.68	63.42 ± 10.83	4.5	0.004	0.03	A>B, C
QoL-Social	68.97 ± 15.96	66.71 ± 21.08	60.32 ± 16.76	66.02 ± 11.13	7.6	<.001	0.05	A, B, D>C
QoL-Environmental	62.97 ± 12.12	59.44 ± 14.30	57.35 ± 13.20	59.93 ± 15.32	3.8	0.01	0.02	A>C

Complex developmental patterns were observed in the domains of QoL. The physical QoL demonstrated the U-shaped pattern with the maximum in Group A (54.10 ± 10.32), the minimum in Group C (49.31 ± 11.14), and the

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slight recovery in Group D (52.88 ± 9.94). Psychological QoL shared the same trend as Group A scoring significantly higher than Groups B and C (Group C 60.32 ± 16.76), which were significantly lower than all others. Environmental QoL did not indicate a significant variation.

- *Bivariate Relationships*

Table 3 shows the correlation matrix. There were weak correlations between age and quality of life domains, which are also non-linear in terms of development. There were insignificant differences in height and weight and QoL. BMI was not correlated with QoL scores. Conversely, HST showed moderate positive relationships with the whole domains of QoL: Physical (r=.40, p<.001), Psychological (r=.38, p<.001), Social (r=.32, p<.001) and Environmental (r=.29, p<.001). Such correlations were always higher as compared to anthropometric variables. There were moderate to strong correlations among the domains of QoL (r=.39-.62, all p<.001).

Table 3 Correlation Matrix for Total Sample (N=455)

Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Age	1								
Height	.62**	1							
Weight	.26**	.62**	1						
BMI	-0.06	.26**	.81**	1					
HST	.33**	.30**	.15**	-0.01	1				
QoL- Physical	-0.04	0	0.02	0.01	.40**	1			
QoL- Psychology	-0.07	-0.01	0.01	0.02	.38**	.62**	1		
QoL- Social	-0.06	-0.01	-0.01	-0.02	.32**	.41**	.51**	1	
QoL- Environmental	-0.04	0.02	0.04	0.04	.29**	.54**	.52**	.39**	1

Note: ** = significant at 0.01 level.

- *Multivariate Prediction of Quality of Life*

Table 4 shows the results of multiple regression. Following the adjustment of age and anthropometric variables, HST was the significant predictor of all four domains of QoL. In the case of Physical QoL, HST has significant contribution to the model [F (5,449) =17.0, (p<.001)], and its contribution can significantly explain the variance (β=.40, p<.001). The same tendencies occurred with Psychological QoL (R^2=.15, β =.38), Social QoL (R^2=.10, β =.32), and Environmental QoL (R^2=.09, β =.29). None of the models were significant in age, height, weight and BMI.

Table 4 Multiple Regression Predicting QoL Domains (N=455)

Predictor	**Physical Health**		**Psychological Health**		**Social Relationships**		**Environmental**	
	β (95% CI)	**p**	**β (95% CI)**	**p**	**β (95% CI)**	**p**	**β (95% CI)**	**p**
Age	-.04 (-.11, .03)	0.39	-.07 (-.14, .01)	0.13	-.06 (-.14, .03)	0.22	-.05 (-.12, .04)	0.3
Height	.01 (-.06, .08)	0.86	-.00 (-.08, .07)	0.97	-.01 (-.09, .07)	0.85	.02 (-.06, .09)	0.7
Weight	.04 (-.05, .13)	0.57	.05 (-.04, .14)	0.45	.04 (-.06, .13)	0.61	.06 (-.04, .15)	0.36
BMI	-.03 (-.11, .07)	0.68	-.05 (-.14, .05)	0.45	-.06 (-.15, .05)	0.41	-.04 (-.13, .06)	0.58
HST	.40 (.30, .50)	<.001	.38 (.28, .48)	<.001	.32 (.22, .42)	<.001	.29 (.19, .39)	<.001
R²	0.16		0.15		0.1		0.09	
Adj. R²	0.15		0.14		0.09		0.08	
F	17		15.5		10.2		8.5	
p	<.001		<.001		<.001		<.001	

- *Developmental Moderation Effects*

The moderation analysis was used to test whether relationship between the HST-QoL and age group differed. The interaction terms (HST x Age Group) were important with Social QoL (ΔR^2=.02, F (3,441) = 3.2, p=.02) but not with other domains. In particular, HST and Social QoL had a positive correlation in older adolescents (Group D: β =.18, p=.04), than in younger adolescents (Group A: β=.42, p<.001). This implies that although fitness is always a predictor of Social QoL, it may have a low relative value as people get older because social aspects have become complex.

- *Mediation Analysis*

Structural equation modelling tested the hypothesized mediation pathway: HST → Physical QoL → Psychological QoL → Social QoL (see Figure 2). The model showed good fit: χ^2 (1) = 2.8, p=.09; χ^2/df = 2.8; CFI=.99; RMSEA=.06 (90% CI: .00, .13); SRMR=.02. Table 5 shows all paths were significant (p<.001):

Table 5 HST and QoL: Sequential Mediation Pathways.

Direct Effects		
Path	Beta (β)	p-value
HST → Physical QoL	0.40	p < .001
Physical QoL → Psychological QoL	0.62	p < .001

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Psychological QoL → Social QoL	0.51	p < .001	
Indirect Effects			
Path	Beta (β)	p-value	95% CI
HST → Psychological QoL (via Physical QoL)	0.25	p < .001	.19, .31
HST → Social QoL (via chain)	0.13	p < .001	.09, .17

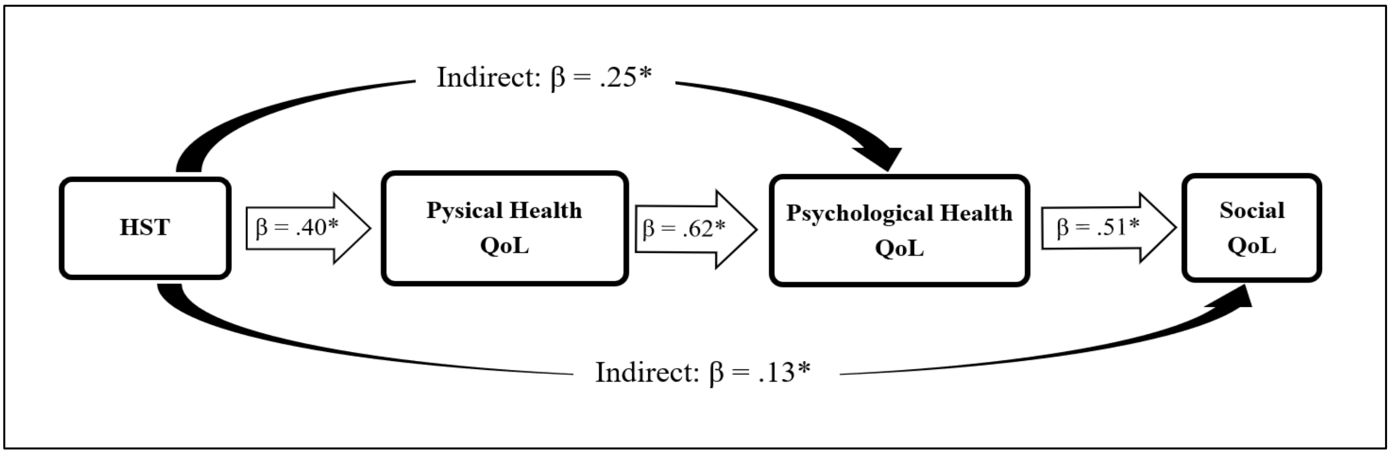

Fig 2 The structural Equation Model: Direct & Indirect Pathways.

This suggests that approximately 63% of HST's effect on Psychological QoL and 41% of its effect on Social QoL operate through these sequential mediation pathways.

➢ *Cluster Analysis of Athlete Profiles*

Clustered analysis based on BMI and HST identified three distinct profiles (Figure 3):

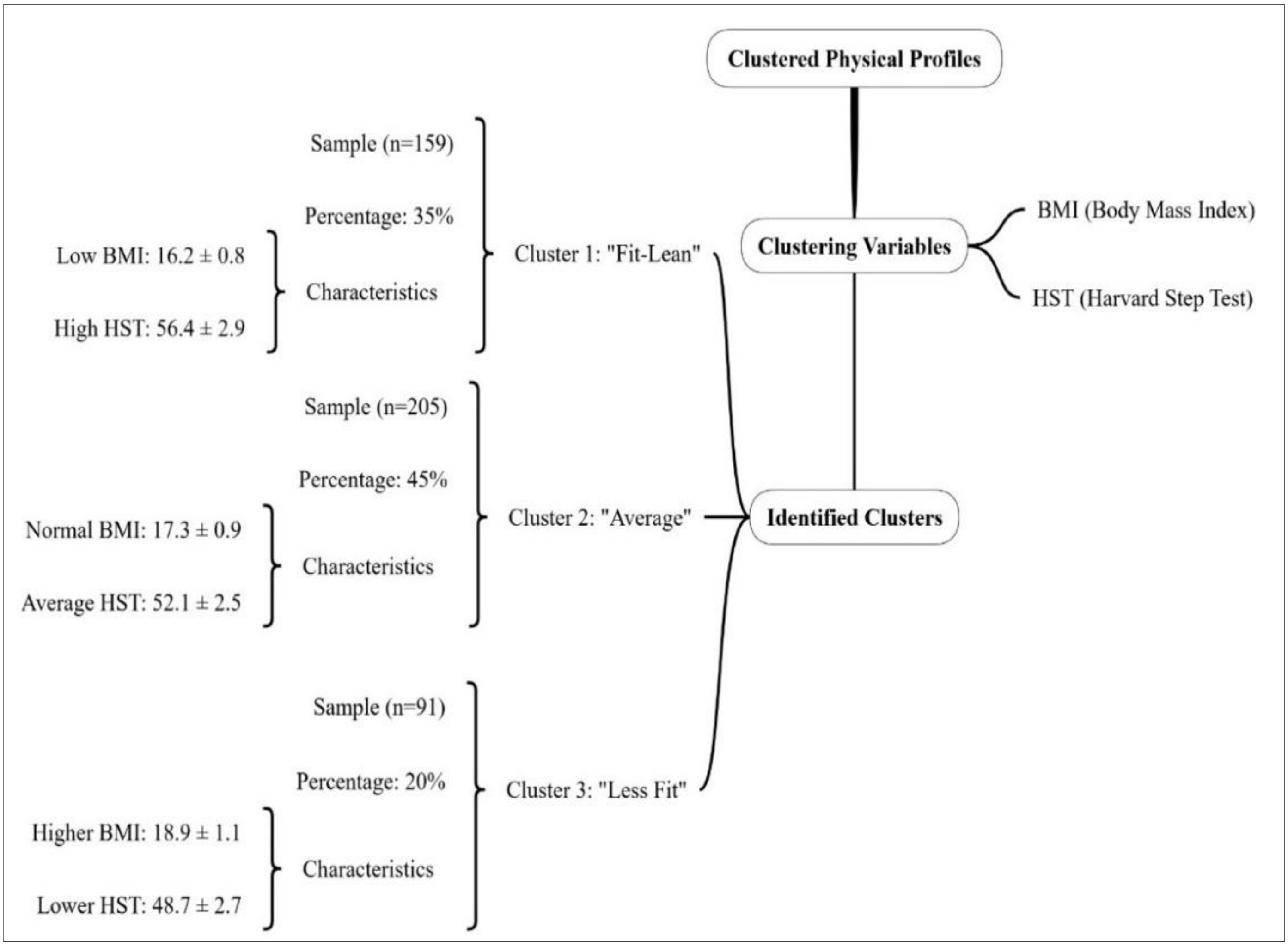

Fig 3 Clustered Physical Profiles of BMI and HST Fitness Groups.

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ANOVA revealed significant QoL differences across clusters (see Table 6). The "Fit-Lean" group demonstrated highest QoL across all domains, followed by "Average," then "Less Fit." Post-hoc tests indicated all pairwise differences were significant (p<.05) except for Environmental QoL between "Average" and "Less Fit."

Table 6 QoL Differences Across Fitness-BMI Clusters*

QoL Domain	Physical Health	Psychological Health	Social Relationships	Environmental
Cluster 1: Fit-Lean (n=159)	55.2 ± 9.8	67.1 ± 12.4	68.9 ± 15.2	61.5 ± 12.9
Cluster 2: Average (n=205)	51.1 ± 11.3	63.0 ± 13.8	64.0 ± 17.8	58.2 ± 14.3
Cluster 3: Less Fit (n=91)	45.8 ± 12.1	57.9 ± 14.5	58.3 ± 17.2	56.1 ± 14.7
F (2,452)	15.6	9.8	10.3	4.5
p	<.001	<.001	<.001	0.012
η^2	0.07	0.04	0.04	0.02
Post-hoc	1>2>3	1>2>3	1>2>3	1>2,3

IV. DISCUSSION

This work contains a thorough understanding of the relationships in development between physical characteristics and quality of life in adolescent football players. Four major findings can also be considered, and they are all theoretical and practical in terms of their implications.

➢ *Developmental Paradox: Improving Fitness but Declining Wellbeing*

We find that the developmental pattern of cardiovascular fitness is paradoxical (linear increase with age as in training adaptations), whereas the QoL (especially social and psychological domains) has a U-shaped pattern of development (with large decreases in the middle of adolescence (14-15 years). The trend is consistent with the literature on adolescent development that describes greater psychosocial vulnerability in mid-adolescence (Patton et al., 2016; Steinberg, 2004), but also goes beyond it by demonstrating that this pattern remains even in the face of the augmenting physical fitness.

This paradox may be explained by a number of mechanisms. First, competitive pressure and performance demands may be increased with advanced age, and this factor can increase stress despite physical readiness (Gustafsson et al., 2017; Rice et al., 2016). Second, academic loads normally increase in the middle adolescence in the Indian school setting, which can lead to issues of sport-academic balance (Deb et al., 2015). Third, psychosocial changes in this stage entail an increase in self-consciousness, social comparison and identity exploration, all potentially more important than the beneficial effects of physical fitness on subjective wellbeing (Harter, 2012; Steinberg & Morris, 2001). The age-related QoL recovery of 15-16 means that there could be adaptation or the development of coping.

➢ *Primacy of Cardiovascular Fitness Over Anthropometrics*

One of the key results is the relative consistency of cardiovascular fitness (HST) over anthropometric predictors of QoL. Although the height, weight and BMI had weak relationships, HST exhibited moderate relationships with all the QoL domains and was the only significant multivariate predictor. It builds up on previous studies that highlight health outcomes with fitness more than fatness (Ortega et al., 2008) to psychosocial wellbeing in sport youth (Eime et al., 2013).

The implications are theoretical in two aspects. First, these results can confirm the hypothesis of fitness that has been proposed based on the regular aerobic exercise (Biddle & Asare, 2011b), which suggests that physiological adjustments can be directly linked to the increase in perceived wellbeing. Second, they question excessive prioritization on anthropometric monitoring among youth sports indicating that development of fitness should be given priority to develop the holistic athlete.

➢ *Developmental Specificity in Fitness-Wellbeing Relationships*

Moderation analysis showed developmental specificity: although HST had a consistent predictive ability of Physical, Psychological and Environmental QoL in any age group, it became associated with Social QoL much weaker in older teenagers. This implies modification of psychosocial relationships wherein social wellbeing is more sensitive to other elements other than physical fitness- maybe peer relationships, coach-athlete relationship or even social identity complexity (Bruner et al., 2017; Holt et al., 2017).

These developmental patterns can be further explained by the sequential mediation model (HST- Physical-Psychological- Social). Fitness has been found to mediate social wellbeing by the effects it has on physical and psychological states, a route which may be more straightforward in early adolescence but which becomes more complicated with age as social cognition is developed.

➢ *The Fit-Lean Profile and Wellbeing Optimization*

Clusters analysis revealed a small number of profiles with a high cardiovascular fitness and low BMI (35% of sample) referred to as a Fit-Lean profile. This population was found to have much better QoL in all domains than the other profiles. Such a combination of fitness and leanness is consistent with optimal models of athlete development (Lloyd et al., 2015) and indicates that joint fitness and body composition interventions could produce the most advantage of wellbeing.

Notably, the group of the Less Fit (higher BMI, lower fitness) demonstrated the lowest results in QoL, which suggests a possible weakness. Targeted intervention based on

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both the development of fitness and the body image issues may be of the most benefit to this subgroup.

V. CONCLUSION

In this cross-sectional analysis of 455 adolescent football players (12-16yrs) proves that cardiovascular fitness is a developmentally strong predictor of quality of life, which is always linked with improved physical, psychological, social and environmental wellbeing in 12-16 years. Conversely, the anthropometric measures (age, height & weight) have weak correlation with perceived wellbeing. The decline in QoL in the middle adolescent 14-15 years despite better fitness also indicates a critical period of time in which physical-psychosocial interventions are essential in sports among adolescence. Subsequent interventions need to focus more on cardiovascular fitness training as well as offering special psychosocial support especially at middle age adolescents of developmental stages.

VI. LIMITATIONS

There are a number of limitations that should be considered. To begin with, the cross-sectional design does not allow making causal conclusions; longitudinal studies must be used to investigate these relationships in the course of time. Second, the sample (male footballers of the same region) is homogeneous and as a result, its generalizability is restricted; it is recommended that female athletes, other sports, and other cultures are considered in the future. Third, the relationships may be confounded by unmeasured variables, such as pubertal status, training load, coaching style, academic pressure. Fourth, QoL measures that are self-reported can be affected by social desirability or response bias.

➢ *Practical Implications*

These findings imply that to coaches, sports scientists, and health professionals dealing with adolescent athletes, the following are implied:

- Prioritize Cardiovascular Fitness: Training programs must also focus on aerobic conditioning to not only have a performance benefit, but also a wellbeing benefit.
- Monitor Mid-Adolescent Wellbeing: It is advisable to focus more on the psychosocial support in this period (14-15) which is a sensitive age in QoL.
- Adopt Holistic Monitoring: Assessment should be conducted both regularly (physical measures, e.g. fitness tests) and psychosocial (QoL measures).
- Target Body Composition Concerns: Fitness is the major concern, but in addition to enhancing fitness, it is essential to consider issues related to unhealthy weight.
- Developmental Programming: Interventions must be developmentally sensitive with the understanding of the varied fitness-wellbeing relationships throughout adolescence.

➢ *Future Directions*

Future studies ought to: (1) use longitudinal studies to follow development patterns; (2) include objective data on physical activity and physiological stress; (3) investigate the role of coaches and parents on athlete wellbeing; (4) test interventions based on both physical development and psychosocial skill acquisition; (5) investigate cultural differences in such relationships.

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