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A STUDY ON THE BODY COMPOSITION OF YOUNG SPORTSPERSONS INTHIRUVANANTHAPURAM, KERALA USING STRUCTURAL EQUATION MODELLING (SEM)

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ABSTRACT

The assessment and monitoring of body composition are imperative for sportspersons since a healthy physique plays a significant role in performance, success, and health. Consequently, sportspeople can assess their health accurately and plan their lifestyle and diet accordingly. The study aimed to analyze the body composition variables and evaluate anthropometry parameters among young sportspersons in Thiruvananthapuram, Kerala. This study was conducted on hundred sportspersons of age group 13-23 years from different colleges in Thiruvananthapuram district, Kerala. All the participants were assessed for Height, Weight, BMI, Waist circumference, Hip circumference, Waist-Hip Ratio and body composition variables such as body fat percentage, water percentage, protein percentage, obesity percentage, bone mass, muscle mass, lean body mass, metabolism, visceral fat and body age. Anthropometry parameters and Body composition variables were measured using standard methods and instruments. The results showed that the anthropometric parameters and body composition variables are statistically significant because their p-values <0.05. On the other hand, the relationship between the BMI and the observed variable, the height is not statistically significant because of its p-value (0.561) which is greater than the usual significance level of 0.05. Thus, the study revealed that there is a moderating effect in the interaction of weight and height on BMI and its effect on various health parameters among sportspeople in the Thiruvananthapuram district, Kerala. In addition to developing a complete health assessment, individuals and health practitioners can monitor body fat and muscle growth to help sportspeople define exercise, diet, and lifestyle changes accordingly, allowing them to take better control of their health with a better understanding of body composition.

Keywords: Body composition – sportspeople – body fat percentage – lifestyle – anthropometry parameters

INTRODUCTION

Human body composition has played a crucial role in monitoring the effectiveness of dietary and training programs for sportsperson. Performance is influenced by many factors, including body composition and body weight. Body composition can change according to sports practice and more generally by physical activity. It is to be considered that each particular sports discipline requires a specific type of training and activity, and this clearly affects athletes' body composition; therefore, it is not possible to apply a rigid notion of optimal body composition to every sport (Thomas et al., 2016). Indeed, in many sports, an athlete can gain an advantage by changing their body mass or body composition features. For example, sports such as gymnastics include both an aesthetic and a gravitational component; thus, anthropometric characteristics may affect a gymnast's success in competitions (Bacciotti et al., 2017)

Anthropometric measurements and body composition are important tools for evaluating the health status as well as nutritional pattern of individuals (Chatterjee et al., 2006). Body composition has an enormous impact on athletic health and performance, making it imperative to develop a reliable, practical and efficient method for computing it.

A structural equation model (SEM) measures and analyzes the relationships between observed and latent variables. Similar but more powerful than regression analyses, it examines linear causal relationships among variables, while simultaneously accounting for measurement error (Beran & Violato, 2010). The advantage of SEM is the simultaneous assessment of all related pathways considering the role of independent and/or dependent (i.e., mediator) factors in outcome development. (Kline, 2015) Literally, SEM is an extension of the general linear model that enables measurement of both direct and indirect effects of variables and incorporate models with multiple dependent variables by using several regression equations simultaneously (Hartwell et al., 2019). Despite concern about the fact that morphological parameters are an essential part of the evaluation and selection of sports persons for diverse fields of sports, standard data on such parameters are still lacking in the Indian context (Shafeeq et al., 2010). There has been no previous study that evaluated associations between BMI and other body composition factors at the same time. Consequently, the current study investigated the associations between BMI and factors such as height, weight, and other body composition factors. Thus, anthropometry and body composition were assessed in sportspersons, with a particular emphasis on Body Composition Analysis (BCA).

Relevance of the study

In evaluating the performance of a diet or aspects relating to an athlete's nutritional status, it is crucial to assess its effectiveness.

It is important for athletes to understand how training affects body composition in order to control their weight and adjust their body composition safely.

Methodology

Subjects

This study was conducted among 100 sportspersons from Thiruvananthapuram district, Kerala (32 males and 68 females) aged 13-24 (18.77±1.92) years. On the first visit, the aim of the study was described for eligible participants and had them time to discuss question with research investigator. All participants gave written informed consent before participating in the study.

Assessment of Anthropometry

The field of anthropometry is used in numerous fields relating to the human body and its supporting equipment. Measurement of body mass index (the ratio between height and weight) is the function of anthropometric tools used in health and sports.

Height

Measurements were taken using a measuring rod with a horizontal cursor that was brought into contact with the subject's highest point. In order to observe the subject's posture and positioning, he must be barefoot and a little dressed. His feet should be joined at the heels, he should stand as straight as possible on a flat surface, and the head should be positioned so that his line of sight is perpendicular to the body. In the background, the subject lies flat and vertically on his back, buttocks, and heels, with his arms hanging freely along his body. Following a deep breath, the subject was measured just before expiration. In order to compress the hair, the movable cursor is brought to contact with the highest point of the head. The height was measured in meters ± 0.1 cm.

Weight

The body mass was measured using an Eagle balance. It is essential that the subject stand upright without assistance. The weight of the body must be evenly distributed over the two feet slightly apart, while the body must stand still in the center of the weighing pan. The shoes should be removed and the subject should be lightly dressed. The body mass was measured in kilograms ± 100 g.

BMI

The Body Mass Index (BMI = kg/hgt m^2) of each individual was calculated by dividing the body weight (in kg) by the square of the height (in m).

Waist Circumference

The waist circumference was measured using an anthropometric tape following standard procedures. The waist circumference was measured on a standing participant along the midline between the lowest border of the rib cage and the iliac crest.

Hip Circumference

In accordance with standard procedures, hip circumferences were measured by using an anthropometric tape. In the standing position, hip circumference was measured at its convex part.

Waist-Hip Ratio (WHR)

The Waist-Hip Ratio (WHR) is calculated by dividing the waist circumference by the hip circumference (HC), both in the same units of measurement.

Determination of body composition

It is a means of characterising the composition of the body, distinguishing between fat, protein, minerals, and body fluids to provide a picture of the health. It more correctly describes the weight and provides a better picture of the overall health than older approaches. Body composition study may show changes in fat mass, muscle mass, and body fat percentage with pinpoint accuracy. Athletes seeking optimal body composition utilise it to improve athletic performance. BCA is a quick and low-cost way to determine whether and how your routines and lifestyle habits are affecting your body and health (DMU, 2021).

Body fat percentage

The primary criteria for evaluating human body composition have typically been % body fat, which is the percentage of total weight represented by fat weight.

Muscle mass

Skeletal Muscle Mass is essential for long-term health and mobility, posture, and immunity. The expected muscular weight in the body. Skeletal muscles, smooth muscles such as heart and digestive muscles, and the water stored in these muscles comprise muscle mass. Muscles consume energy by acting as an engine. As muscle mass increases, so does the pace at which the body burns energy (calories), which accelerates the basal metabolic rate (BMR) and aids in the reduction of excess body fat levels and weight loss in a healthy manner. Exercising vigorously can increase muscle mass while also increasing overall body weight.

Bone mass

The Bone Mass feature estimates the weight of bone mineral using a statistical computation based on skeleton size and Fat Free Mass.

Visceral fat

Visceral fat is a form of body fat found in the abdominal cavity. It is close to various essential organs such as the liver, stomach, and intestines.

Water percentage

Total Body Water (TBW) is separated into two categories: extracellular water (ECW) and intracellular water (ICW). For optimal health, it is essential to maintain a healthy body water balance.

Protein percentage

The protein component of the human body makes up 18% of its total mass and is crucial for cell structure and function. Muscle cells contain a significant amount of protein, which is an important indicator of nutritional status, physical development, and health of the individual.

Obesity percentage

It is about the degree of obesity, which indicates the difference between the actual weight and the ideal weight. Obesity degree is an indicator of obesity.

obesity = (actual weight-ideal body weight)/ideal weight * 100%

Lean body mass

Lean body mass includes water, muscle, bone, connective tissue, and internal organs as well as total body water and lean mass.

Metabolism

BMR is the number of calories required by the body to perform its most basic life-sustaining processes. Even when in rest, the body burns calories by performing basic life-sustaining tasks such as breathing, circulation, nutrient digestion, cell creation, and so on. BMR and resting metabolic rate are terms that are frequently used interchangeably. The BMR is the calorie requirement for fundamental processes at rest.

Body age

The core principle behind biological age is that ageing happens gradually as damage to various cells and tissues in the body accumulates. It's sometimes referred to as physiological or functional age. Biological age differs from chronological age in that it takes into account factors other than the day of birth. Biological age might change depending on the lifestyle, nutrition, exercise, sleep, attitude, stress, and other factors. This will be higher or lower than the chronological age depending on the genetics and lifestyle.

Statistical Analysis

Several conceptual frameworks have been developed to illustrate possible interactions between the latent variables

SEM was performed using a AMOS 20 software. Model fit was assessed using the following fit indices: χ 2 , Normed Fit Index (NFI), Comparative Fit Index (CFI) and Root-Mean-Square Error Of Approximation (RMSEA). A non-significant χ 2, NFI or CFI equal to or greater than 0·950, and an RMSEA less than or equal to 0·070 represent a good fit for the data. At p-values below 0.05, regression coefficients (ß) were used to measure associations between the research variables. Testing and evaluating the goodness-of-fit indices were conducted using analysis of moment structure (AMOS, version 21.0).

Results and discussions

STRUCTURAL EQUATION MODELLING

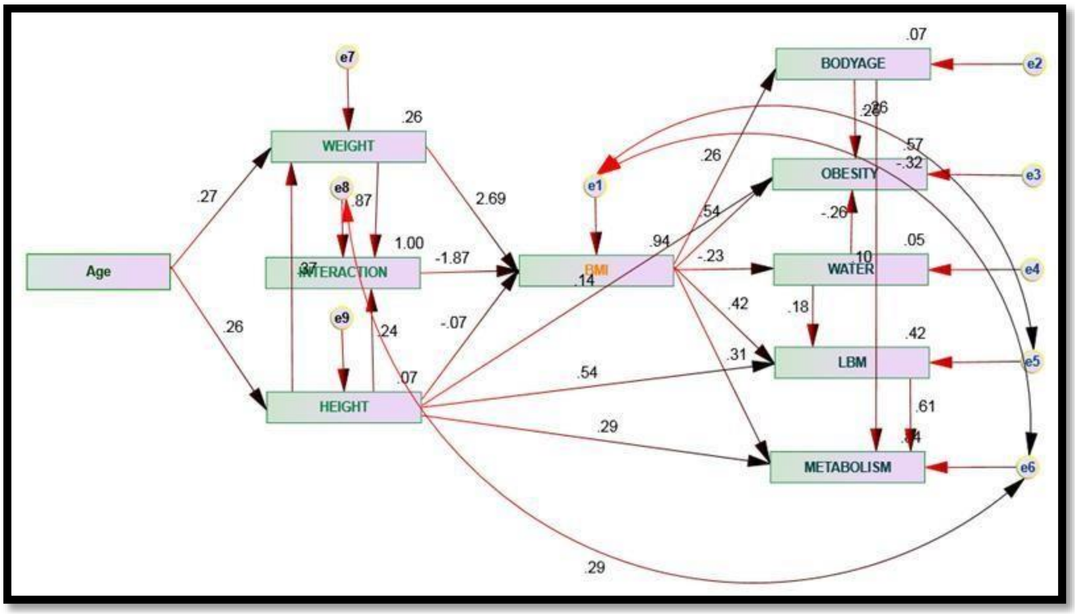

Fig 1. Path analysis diagram with standardized estimates illustrating the moderating effect on the interaction of weight and height on BMI and its effect on various health parameters among sports professionals.

Abbreviations: BMI, Body Mass Index; LBM, Lean Body Index. All path coefficients are standardized. Red arrows mean p.value ≤ 0.05. Total effect is defined as the sum of direct and indirect effects.

GOODNESS OF FIT INDEX

Table 1: RMSEA

RMSEA

Model	**RMSEA**	LO 90	HI 90	PCLOSE
Default model	**.070**	.000	.118	.248
Independence model	.530	.506	.555	.000

From table 1, Root mean square error of approximation (RMSEA) is 0.070. The value of interest here is represented by RMSEA in the default model field where values ≤ 0.05

indicate a better model fit (MacCallum et al., 1996). Values ranging from 0.05 to 0.08 are considered acceptable and suggest reasonable errors of approximation with 90% confidence interval.

Table 2: RMR, GFI

RMR, GFI

Model	**RMR**	**GFI**	**AGFI**	PGFI
Default model	**185.695**	**.949**	**.966**	.362
Saturated model	.000	1.000		
Independence model	557.042	.349	.204	.285

RMR is 185.695, the smaller the RMR value the better. GFI is .949 and the value is ≤1, which represents a perfect fit. AGFI is .966, also indicates a perfect fit.

Table 3: CMIN

CMIN

Model	NPAR	**CMIN**	**DF**	**P**	**CMIN/DF**
Default model	34	**31.109**	**21**	**.072**	**1.481**
Saturated model	55	.000	0		
Independence model	10	1297.629	45	.000	28.836

The value of interest here is the CMIN/DF for the default model. CMIN/DF is 1.481, If the CMIN/DF value is ≤ 3 it indicates an acceptable fit (Kline, 2015).

Table 4: Baseline Comparisons

Baseline Comparisons

Model	**NFI Delta1**	**RFI rho1**	**IFI Delta2**	**TLI rho2**	**CFI**
Default model	.976	.949	.992	.983	.992
Saturated Model	1.000	1.000	1.000		
Independence model	.000	.000	.000	.000	.000

The CFI, TLI, IFI, RFI and NFI are above .95 which indicates a good fitting model. The value of interest here is CFI for the default model. A CFI value of ≥ 0.95 is considered an excellent fit for the model (West et al., 2012).

GOODNESS OF FIT INDICES – SUMMARY

Table 5: Goodness of fit indices

INDICES	RECOMMENDED VALUE	INDEX VALUE	INTERPRETATION
Chi-square value CMIN	p-value should be > .05	31.109	-
Degree of Freedom DF	-	21	-
P-Value	≤.05	0.072	Accepted fit
CMIN/DF (discrepancy divided by degree of freedom)	≤3	1.481	Accepted fit
Comparative Fit Index (CFI)	≥0.95	0.992	Excellent fit
Goodness of Fit Index (GFI)	≥0.95	0.949	Excellent fit
Adjusted Goodness of Fit Index (AGFI)	≥0.95	0.966	Excellent fit
Root Mean Square Residual (RMR)	<0.05	185.695	-
Root mean square error of approximation (RMSEA)	≤0.05	0.070	Reasonable fit
Normed Fit Index (NFI)	≥0.95	0.976	Excellent fit
RFI	≥0.95	0.949	Excellent fit
IFI	1	0.992	Excellent fit
TLI	≥0.95	0.983	Excellent fit

Source: (Lomax, 2011)

The goodness-of-fit test statistics are displayed below. Root mean square error of approximation (RMSEA) is 0.070 and the value less than 0.05, indicates a good fit. Values up to .080 suggest a reasonable errors of approximation with 90% confidence interval. Goodness of Fit Index (GFI) is 0.949 and Adjusted Goodness of Fit Index (AGFI) is 0.966 are larger than 0.9 which again reflect a good fit although GFI and AGFI may not be as informative as Chi-square test statistics and RMSEA. Each of the fitting index values (CMIN=31.109, CMIN/DF=1.481, RMSEA=0.070, DF=21, P=0.072, RMR=185.695, GFI=0.949, AGFI= 0.966, NFI= 0.979, RFI=0.976, IFI=0.992, TLI=0.983, CFI=0.992) outperformed the respective threshold values, satisfying that the model satisfactorily incorporated the data. Furthermore, a good model should have a CFI value greater than 0.90.

Table 6: Regression Weights

Regression Weights: (Group number 1 - Default model)

			Estimate	S.E.	C.R.	P	Label
HEIGHT	<---	Age	.012	.004	2.630	.009	
WEIGHT	<---	Age	1.521	.511	2.975	.003	
WEIGHT	<---	HEIGHT	47.471	11.335	4.188	***	
INTERACTION	<---	WEIGHT	1.613	.011	151.211	***	
INTERACTION	<---	HEIGHT	56.464	1.353	41.727	***	
BMI	<---	INTERACTION	-.377	.097	-3.902	***	
BMI	<---	HEIGHT	-3.265	5.619	-.581	.561	
BMI	<---	WEIGHT	1.011	.156	6.464	***	
WATER	<---	BMI	-.313	.135	-2.308	.021	
BODYAGE	<---	BMI	.241	.091	2.649	.008	
LBM	<---	HEIGHT	52.853	7.442	7.102	***	
LBM	<---	WATER	.266	.112	2.388	.017	
LBM	<---	BMI	.861	.165	5.211	***	
OBESITY	<---	BMI	2.335	.302	7.731	***	
METABOLISM	<---	BMI	14.548	2.078	7.000	***	
METABOLISM	<---	HEIGHT	640.637	104.637	6.122	***	
METABOLISM	<---	BODYAGE	4.968	1.812	2.741	.006	
OBESITY	<---	HEIGHT	28.871	13.558	2.129	.033	
OBESITY	<---	WATER	-.815	.211	-3.859	***	
OBESITY	<---	BODYAGE	1.149	.314	3.658	***	
METABOLISM	<---	LBM	13.891	1.100	12.623	***	

Table 7: Standardized Regression Weights

Standardized Regression Weights: (Group number 1 - Default model)

			Estimate
HEIGHT	<---	Age	.256
WEIGHT	<---	Age	.266
WEIGHT	<---	HEIGHT	.374
INTERACTION	<---	WEIGHT	.869
INTERACTION	<---	HEIGHT	.240
BMI	<---	INTERACTION	-1.866
BMI	<---	HEIGHT	-.069
BMI	<---	WEIGHT	2.695
WATER	<---	BMI	-.226
BODYAGE	<---	BMI	.257
LBM	<---	HEIGHT	.545
LBM	<---	WATER	.181
LBM	<---	BMI	.422
OBESITY	<---	BMI	.539
METABOLISM	<---	BMI	.315
METABOLISM	<---	HEIGHT	.291
METABOLISM	<---	BODYAGE	.101
OBESITY	<---	HEIGHT	.140
OBESITY	<---	WATER	-.260
OBESITY	<---	BODYAGE	.249
METABOLISM	<---	LBM	.612

When there is one degree deviation (SD) change in age. The corresponding change in the SD in Height is .012 times. The Standard Error (SE) is 0.04, Critical Rate (CR) is 2.630, P Value is .009 which is significant (<0.05).When there is one degree deviation (SD) change in age. The corresponding change in the SD in Weight is 1.52 times. The Standard Error (SE) is .511, Critical Rate (CR) is 2.975, P Value is .003 which is significant (<0.05).When there is one degree deviation (SD) change in height. The corresponding change in the SD in Weight is 47.47 times. The Standard Error (SE) is 11.33, Critical Rate (CR) is 4.18, P Value is .000 which is significant (<0.05).When there is one degree deviation (SD) change in Weight. The corresponding change in the SD in interaction is 1.61 times. The Standard Error (SE) is .011, Critical Rate (CR) is 151.21, P Value is .000 which is significant (<0.05).When there is one degree deviation (SD) change in height. The corresponding change in the SD in interaction is 56.46 times. The Standard Error (SE) is 1.35, Critical Rate (CR) is 41.72, P Value is .000 which is significant (<0.05).When there is one degree deviation (SD) change in interaction. The corresponding change in the SD in BMI is -.377 times. The Standard Error (SE) is .097, Critical Rate (CR) is -3.902, P Value is .000 which is significant (<0.05).When there is one degree deviation (SD) change in height. The corresponding change in the SD in BMI is -3.265 times. The Standard Error (SE) is 5.619, Critical Rate (CR) is -.581, P Value is .561 which is not significant (<0.05).When there is one degree deviation (SD) change in weight. The corresponding change in the SD in BMI is 1.01 times. The Standard Error (SE) is 0.156, Critical Rate (CR) is 6.46, P Value is .000 which is significant (<0.05).When there is one degree deviation (SD) change in BMI. The corresponding change in the SD in water is .313 times. The Standard Error (SE) is .135, Critical Rate (CR) is 2.308, P Value is .021 which is significant (<0.05). When there is one degree deviation (SD) change in BMI. The corresponding change in the SD in Body age is .241 times. The Standard Error (SE) is 0.091, Critical Rate (CR) is 2.64, P Value is .008 which is significant (<0.05). When there is one degree deviation (SD) change in height. The corresponding change in the SD in LBM is 52.85 times. The Standard Error (SE) is 7.44, Critical Rate (CR) is 7.10, P Value is .000 which is significant (<0.05). When there is one degree deviation (SD) change in water. The corresponding change in the SD in LBM is 0.266 times. The Standard Error (SE) is 0.112, Critical Rate (CR) is 2.38, P Value is .017 which is significant (<0.05).When there is one degree deviation (SD) change in BMI. The corresponding change in the SD in LBM is .86 times. The Standard Error (SE) is 0.165, Critical Rate (CR) is 5.21, P Value is .000 which is significant (<0.05). When there is one degree deviation (SD) change in BMI. The corresponding change in the SD in obesity is 2.33 times. The Standard Error (SE) is 0.302, Critical Rate (CR) is 7.731, P Value is .000 which is significant (<0.05). When there is one degree deviation (SD) change in BMI. The corresponding change in the SD in metabolism is 14.54 times. The Standard Error (SE) is 2.078, Critical Rate (CR) is 7.00, P Value is .000 which is significant (<0.05).When there is one degree deviation (SD) change in height. The corresponding change in the SD in metabolism is 640.63 times. The Standard Error (SE) is 104.63, Critical Rate (CR) is 6.122, P Value is .000 which is significant (<0.05). When there is one degree deviation (SD) change in height. The corresponding change in the SD in obesity is 28.871 times. The Standard Error (SE) is 13.55, Critical Rate (CR) is 2.12, P Value is .033 which is significant (<0.05).When there is one degree deviation (SD) change in water. The corresponding change in the SD in obesity is -.815 times. The Standard Error (SE) is 0.211, Critical Rate (CR) is -3.859, P Value is .000 which is significant (<0.05). When there is one degree deviation (SD) change in body age. The corresponding change in the SD in obesity is 1.14 times. The Standard Error (SE) is 0.314, Critical Rate (CR) is 3.65, P Value is .000 which is significant (<0.05). When there is one degree deviation (SD) change in LBM. The corresponding change in the SD in metabolism is 13.891 times. The Standard Error (SE) is 1.10, Critical Rate (CR) is 12.62, P Value is .000 which is significant (<0.05).

When the critical ratio (CR) is > 1.96 for a regression weight, that path is significant at the .05 level or better (that is, its estimated path parameter is significant) except for Height on BMI (where CR is -.581, P-Value is .561). In the p-value column, three asterisks (***) indicate significance smaller than .001.

Table 8: Covariances

Covariances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
e5 <--> e1	-1.701	.705	-2.411	.016	
e6 <--> e8	22.588	8.180	2.761	.006	
e6 <--> e1	-24.836	7.854	-3.162	.002	

All the parameter estimates are high significant. In other words, all of them are statistically significant. The interpretations on the parameter estimates are straight forward. There is a covariance between error on BMI (e1) of LBM (e5), p-value is .016 (<0.05). The correlation structure between e6 and e8, e6 and e1 is also estimated by AMOS with significant results.

Table 9: Correlations

Correlations: (Group number 1 - Default model)

	Estimate
e5 <--> e1	-.257
e6 <--> e8	.290
e6 <--> e1	-.321

There is a correlation between e5 (LBM) and e1 (BMI) is -.257. There is a correlation between e6 (metabolism) and e8 (interaction) is .290. There is a correlation between e6 (Metabolism) and e1 (BMI) is -.321.

Table 10: Squared Multiple Correlations

Squared Multiple Correlations: (Group number 1 - Default model)

	Estimate
HEIGHT	.065
WEIGHT	.261
INTERACTION	.997
BMI	.936
WATER	.051
LBM	.418
BODYAGE	.066
METABOLISM	.845
OBESITY	.572

For calculating the overlap between predictors and outcomes, a square multiple correlation is typically used. As shown in the example, R-squares range from 0.5 to highly high values such as 0.93 and 0.99. The smallest R-square is 0.50 for predicting the presence of water%. As a result, this is actually not a very low R-square value for social science data. Although interaction has a high R-square (0.99), this is an exceptional value. Consequently, interaction can be accurately predicted by Height, Weight, and Age.

Summary and conclusion

In sports and activities, body composition and physique have a direct impact on performance. The body composition of sportsperson can be used to determine what their optimal competitive body weight should be, to assess their health, and to monitor training effects. Based on structural equation modeling, we found that weight and height had a moderating effect on BMI, as well as its effect on health parameters of athletes.

In order to be able to take better control of their health, individuals and health practitioners need to develop a comprehensive health assessment, track body fat and muscle growth, and determine exercise, diet, and lifestyle changes accordingly.

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