Journal of Exercise Physiologyonline

June 2017
Volume 20 Number 3

JEMonline

Published by the American Society of Exercise Physiologists

ISSN 2378-4083

Estimate of Body Fat Percentage in Male Volleyball Players: Assessment Based on Skinfolds

Yuri Germano Muniz[1], Marco Cossio-Bolaños[1,2,3] Rossana Gómez-Campos[1,4], Ezequiel Moreira Gonçalves[5], Evandro Lázari[1], Camilo Urra-Albornoz[6], Miguel de Arruda[1]

[1]Faculty of Physical Education, State University of Campinas, São Paulo, Brazil, [2]Department of Physical Activity Sciences, Catholic University of Maule, Talca, Chile, [3]Universidad Nacional de San Agustín, Arequipa, Perú, [4]Instituto de Actividad Física y Salud, Universidad Autonoma de Chile, Talca, Chile, [5]Growth and Development Lab, Center for Investigation in Pediatrics (CIPED), School of Medical Sciences (FCM), University of Campinas (UNICAMP), Campinas-SP, Brazil, [6]Escuela de Kinesiología, Facultad de salud, Universidad Santo Tomás, Talca, Chile

ABSTRACT

Germano-Muniz Y, Cossio-Bolaños M, Gómez-Campos R, Moreira-Goncalves E, Lazari E, Urra-Albornoz C, Arruda M. Estimate of Body Fat Percentage in Male Volleyball Players: Assessment Based on Skinfolds. **JEPonline** 2017;20(3):14-24. The purpose of the study was to develop regression equations to predict body fat percentage (BF%) in young male volleyball players by using the Dual-energy X-ray absorptiometry (DXA) method as a reference. The subjects consisted of 29 volleyball players (16.0 to 20.9 yrs of age) from a professional first division team in the Brazilian volleyball league. The subjects' years of experience, weight, height, sitting height, and 7 skinfolds (triceps, biceps, subscapular, iliac crest, abdominal, front thigh, and medial calf) were determined. Three equations were created to predict BF%: (a) Equation 1, (R^2 = 0.76, SEE = 1.82); (b) Equation 2, (R^2 = 0.79, SEE = 1.85); and (c) Equation 3, (R^2 = 0.80, SEE = 1.81). All three equations developed may be used to predict BF% in young volleyball players. These equations may also be used as a reliable and valid alternative technique for research.

Key Words: Absorptiometry, Anthropometry, Body Fat Percentage, Dual-Energy X-Ray, Volleyball Players

INTRODUCTION

Volleyball is an engaging and intense sports modality. It is practiced worldwide at amateur, professional, and Olympic levels. According to the International Volleyball Federation (IVBF), volleyball is played in 220 affiliated countries worldwide. It is characterized by athletes who are involved in intense short physical efforts, both during training and competition (25).

The physical, technical, and tactical superiority shown by most of the successful teams suggest the need for excellent training programs in order to obtain a high competitive level (21). Moreover, the assessment of athletes and the monitoring of their performance should be consistently carried out in all stages of sports periodization. Both allow for engaging the athletes in necessary training to help define and grow the sport of volleyball and its players.

With regard to sports assessment in particular, there are a complex and diversified group of variables to consider. In particular, there are physical and physiological factors to exam in addition to the athletes' psychological, biomechanical, hematological, technical, tactical, and morphological profiles. Fortunately, there are numerous studies that have documented the physiological, anthropometrical, and physical characteristics of volleyball players (7,18,23, 25). But, from our perspective, studies related to body composition in young volleyball players are non-existent. This is especially the case when it comes to studies that have researched specific regression equations in order to predict body fat percentage in young elite volleyball players. This is a concern since the constant monitoring of body composition is crucial for athletes who participate in diverse sports modalities, not solely from the point of view of health, but also of performance (28). Additionally, it may be beneficial in terms of specific training program optimization (3) and in talent detection (12).

Consequently, body composition measurement may be very beneficial to managers, trainers, and nutritionists linked to sports since they may deem field techniques as more reliable than laboratory techniques (4). Field techniques (such as the skinfold thickness measurement) are characterized by their ease and simplicity in their everyday use, low costs (1,14,19), and implementation.

From this perspective, the development of regression equations for male volleyball players based on skinfold thickness measurements should be helpful compared to general equations developed for the non-athletic population. After all, athletes often have less body fat% and higher muscle mass when compared to the general population (4). Also, it is important to point out that each sports modality, regardless of the athletes' performance level, presents its own anthropometric and compositional body patterns. Thus, the purpose of this study was to develop sport-specific regression equations to predict the body fat percentage in young male volleyball players.

METHODS

Subjects

A descriptive-explanatory study was carried out with 29 volleyball players (16.0 to 20.9 yrs of age). The athletes were selected from a first division professional team from the Brazilian volleyball league. They were selected non-probabilistically. According to their positions on the court, the players assessed belonged to the following categories: Setter (n = 6), Middle blocker (n = 9), Hitter (n = 8), Opposite (n = 3), and Libero (n = 3). All players evaluated were in good health (as defined by being free from diabetes, heart ailments, muscular-skeletal dysfunctions, cancer, and smoking). At the time of the assessment (the beginning of the competitive season), the volleyball players were training 6 times·wk^{-1} at ~3 hrs·session^{-1}.

Parents of the volleyball players who were <18 yrs of age gave their informed consent for the player to participate in the study. They were previously informed about any potential risks the study might have for the young players. Athletes 18 yrs of age and above gave consent themselves to participate in the assessments. The study was approved by the ethics committee of the Medical School from the Universidad Estadual de Campinas de Sao Paulo (Brazil).

Procedures

Anthropometric variants and the Dual-energy X-ray absorptiometry were carried out on the same day. All evaluations took place in one week during the month of August, 2013 from 9:00 to 11:00 am. The whole process was conducted in a laboratory of the Medical School of the University of Campinas (Brazil).

Body mass index, size, and skinfolds were measured without any footwear on. Players were dressed in light clothing. The International Society for Advancement of Kinanthropometry (15) protocol was followed during the measurements. Body mass index (kg) was measured barefoot using a digital scale (Tanita Company, Ltd) with a precision of 0.1 kg. Bicipital, tricipital, subscapular, iliac crest, abdominal, front thigh, and medial calf skinfolds were measured using a Harpenden Skinfold Caliper (Harpenden, England). The pressure applied by the grasp of the tool was tested in accordance with the manufacturer's specifications. A specialized ISAK certified technician was in charge of overseeing the anthropometric assessments. Intra-rater technical error of measurement (TEM) was inferior to 2% in all of the anthropometric measurements.

The Dual-energy X-ray absorptiometry (model iDXA, GE Healthcare Lunar, Madison, WI, USA) was used as the referential method to analyze body composition. For the data analysis, the software enCore™ 2011, version 13.60 (GE Healthcare Lunar, Madison, WI, USA) was used. All subjects were warned about wearing jewelry, the presence of any sort of metal in the body. They were also required to remove their footwear during the scanning. Every day, prior to any assessment, the technician was in charge of calibrating the equipment according to the manufacturer's specifications. Prior to the study, the technician received training and certification for the professional use of the equipment.

During the scanning, the subjects remained in a supine position with their arms outstretched by their sides and with knees and ankles restrained with Velcro straps in order to maintain a standard stance. Reference points were adjusted according to guidelines displayed by the software. The jaw line was used for carrying out an accurate reading of head minus body composition. These adjustments had to be performed as the athletes' height exceeded that of the scanner platform. All subjects were told to remain in a resting position while they were scanned (motionless).

Statistical Analysis

Data normality was verified by using the Shapiro-Wilk test. Descriptive analysis of the arithmetic mean (X), standard deviation (SD), range, Z-score, and coefficient of variation (CV) were used. In order to connect variables with the reference, the Pearson product-moment correlation coefficient was utilized. In turn, to develop the regression equations, multiple regression analysis was run in steps to identify the variables that best predicted body fat percentage (%) in the volleyball payers. In order to analyze the equations, R^2, Standard error of estimate (SEE) and Multicollinearity were estimated through the Variance inflation factor (VIF). Differences between the reference method (DXA). The rest of the equations developed were verified through the Paired samples *t*-test. The entire statistical analysis was conducted with SPSS Statistics v.18. A probability of P<0.001 was adopted for statistical significance.

RESULTS

Table 1. Anthropometric Characteristics of Volleyball Players.

Variables	X	SD	Minimum	Maximum
Age (yrs)	18.1	1.2	16.40	20.2
Professional Experience (yrs)	4.5	1.6	2.0	8.0
Height (cm)	193.8	7.3	169.8	208.4
Sitting Height (cm)	150.1	3.8	140.5	157.5
Weight (kg)	84.9	10.7	63.7	109.8
Skinfolds (mm)				
Biceps	5.2	2.3	3.0	12.7
Tricipital	10.9	3.3	5.0	17.8
Subscapular	11.8	2.4	8.0	16.7
Iliac crest	13.4	4.8	6.7	25.8
Abdominal	15.3	6.0	6.2	26.5
Front thigh	12.9	4.5	6.5	21.8
Medial calf	9.4	3.3	4.2	17.3
DXA				
Fat %	16.4	3.7	10.1	21.7
Fat mass	14.0	4.0	7.6	22.9
Lean soft tissue	67.2	8.1	50.5	82.1
Bone mass content	3.7	0.4	2.8	4.4

X = Mean; **SD** = Standard deviation; **DXA** = Body Composition

Proposed regression equations for young volleyball players are displayed in Table 2. All equations use skinfolds as predictive variables of body fat percentage. The R^2 values depict a statistical power between 76% to 80%. The SEE values are relatively similar in all of the equations, which vary between 1.80 to 1.85. All equations show P<0.001. In Figure 1, the similarity of the observed and predicted residuals can be observed.

Table 2. Body Fat% Regression Equations Based on Skinfolds and Variance Inflation Factor (VIF).

	Equations	VIF	R	R^2	SEE	P
Equations						
1	8.64+(0.68*Tr)-(0.42*Sb)+(0.39*I)	--	0.89	0.76	1.82	0.000
	Tricipital	2.64				
	Subscapular	1.73				
	Iliac crest	2.31				
2	8.55+(0.63*Tr)-(0.42*Sb)+(0.38*I)+(0.06*T)	--	0.89	0.79	1.85	0.000
	Tricipital	3.51				
	Subscapular	1.74				
	Iliac crest	2.47				
	Front thigh	2.54				
3	8.26+(0,57*Tr)-(0.42*Sb)+(0.40*I)-(0.15*Mc)	--	0.89	0.80	1.81	0.000
	Tricipital	3.60				
	Subscapular	1.74				
	Iliac crest	2.32				
	Medial calf	1.82				

Tr = tricipital; **Sb** = Subscapular; **I** = Iliac crest; **T** = Front thigh; **Mc** = Medial calf; **SEE** = Standard error of estimation; (P<0.001).

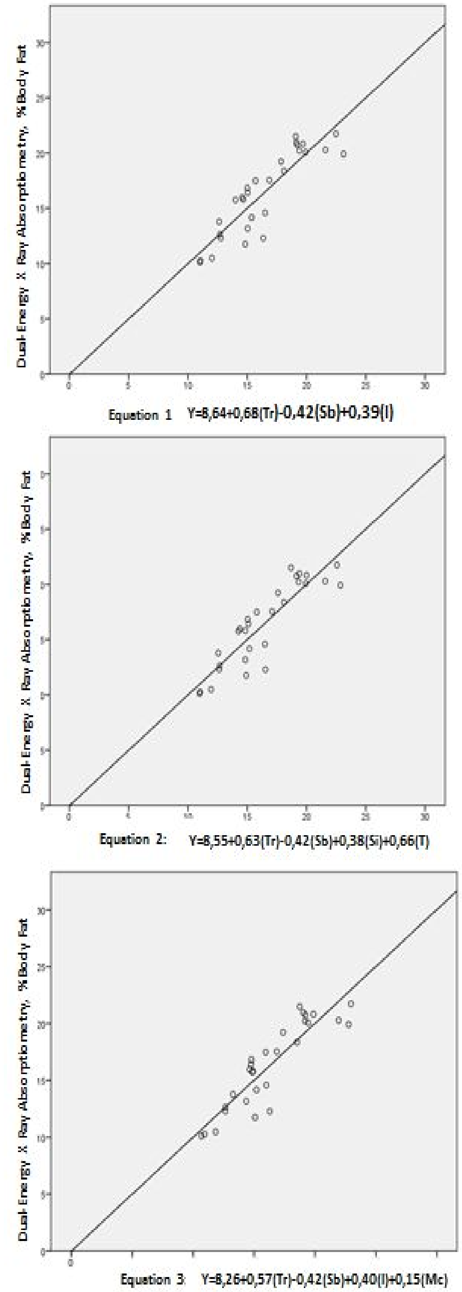

Figure 1. Dispersion Graph of Observed Values through Referential Method (DXA) and Values Predicted by the Three Regression Equations.

Table 3 depicts the descriptive statistical values of body fat percentage based on the referential method (DXA) and the three developed equations. No significant discrepancies occurred between the referential method and each of the three equations (P>0.001) developed. Additionally, the three proposed equations presented a high correlation coefficient with the referential method (R = 0.88-0.90, P<0.001) and coefficient of variation inferior to 22%.

Table 3. Comparison of Body Fat Percentage (BF%) Estimated with DXA and Regression Equations Based on Skinfolds.

Methods	N	X	SD	Range Minimum	Range Maximum	CV	r	*t*-test
BF%								
Reference 1	29	16.4	3.7	10.1	21.7	22.6	--	--
Equation 1	29	16.4	3.3	10.9	23.1	20.2	0.888**	0.995
Equation 2	29	16.1	3.2	10.5	22.2	19.97	0.895**	0.733
Equation 3	29	16.4	3.3	10.9	22.8	20.1	0.889**	0.993

BF% = Body fat percentage; **1** = Estimated with DXA; **SD** = standard deviation; **r** = Pearson product-moment correlation coefficient; **CV** = Coefficient of variation; ****** = significant discrepancies (P<0.001).

DISCUSSION

In this study, three regression equations were developed in order to predict the BF% in young volleyball players. These equations show a statistical power that oscillates between 76 to 80%. The values (R^2) are similar to those in studies carried out with athletes (22,29) and non-athletes (5,16). However, in other studies (6,20), the researchers found in their equations relatively superior values in relation to those observed in this study.

In fact, as far as we are aware, no actual consensus exists regarding the criteria to identify the best equations for predicting body fat percentage. However, some studies conducted by Goran et al. (10) and Yaravi et al. (30) are based on statistical significance analysis (P-values). On the other hand, Cameron et al. (2) and Gartner et al. (8) maintain that the selection of equations can include the adjusted R^2. Finally, Stevens et al. (26) base their selection on the SEE. As to the present study, we opted for considering the three criteria as a whole, with the main goal to identify those equations that would best predict BF% in young Brazilian volleyball players. Additionally, it should be noted that a fourth requirement was added. Its main objective was to verify the precision of regression coefficients through multi-colinearity.

The variance inflation factor (VIF) varied in all three equations, from 1.7 to 3.6. In fact, few studies have found values like these (9,20). Unlike R^2, significance analysis and SEE are much more common despite what is suggested in the literature with regard to the use of VIF as a general rule in the estimation of body composition (13). Researchers even pointed out that VIF values should not surpass that of 10. Therefore, in keeping with our results, the three equations depicted values <10, showing a similar precision in predicting BF%. These equations may be used and/or applied to other samples due to their high predictive capacity for BF% in young volleyball players.

Each equation showed high statistical power, as previously stated (76 to 80%). Additionally, in Figure 1, the similarity between the observed and determined residuals is visible. The distribution of variables is normal in all three equations. With regard to the Standard Error of Estimate, coincidentally, the three equations showed values <1.85%. These values are similar and/or less than the values in other studies (6,20,24) and even further below the criterion established by Lhoman (17), where values <3% are suggested. Furthermore, it is important to emphasize that in relation to significance, all proposed equations showed a P<0.0001.

Consequently, the three new equations encompassed all four criteria analyzed. The equations may be characterized as precise methods of determining BF%. They may also be used to avoid some sort of result interpretation bias. Each equation was compared to the reference (DXA). In fact, no significant discrepancies were observed in any of the equations (P<0.001). The coefficients of variation were inferior to that of the reference (<22.6%). This was even true at 33% used in statistical terms, and is generally applied to variables that originated in the same and/or different sample in order to compare the dispersion between the distributions.

Therefore, these three new equations are available to estimate BF% in young Brazilian volleyball players. They may also be used by sports and health science professionals. The professionals may choose the equation that best fits the profile of their athletes as well as the training programs and/or resources available in their respective clubs.

In general terms, in order to estimate BF% in volleyball players, it is necessary to assess triceps, subscapular, iliac crest, front thigh, and medial calf skinfolds since these anatomical points suggest the prediction of BF% in a more precise manner in young volleyball players. This is not the case for the bicipital and abdominal skinfolds, despite having been submitted to a rigorous process of predictive variables selection where VIF values resulted superior to the limit of 10, and R^2 showed a considerable reduction to 10%, respectively.

Limitations of this Study

Some limitations occurred in this study. For instance, athletes' scanning (DXA) was conducted from the jaw line downwards. This was carried out in order to ensure an accurate reading of headless body mass composition. Due to the body size of the volleyball athletes, it was difficult to properly place them into the frame on the scanner platform. This might create some kind of bias that could influence the results. It is necessary to take this aspect into consideration at the time of analyzing the results.

On the other hand, cross-validation was not conducted on 10% of the original sample since it was not representative to generalize the results. Future studies should take into consideration these aspects and propose additional equations, not solely for BF%, but also to propose new compartmental models to analyze body composition of volleyball players.

As for the strengths of the study, we emphasize the few technical errors observed (intra-rater) in measurements of skinfolds assessment. In fact, control of anthropometric measurement quality implies the reduction of measurement errors since it is even considered as a prerequisite that would allow a better interpretation of the results. This would allow for a better interpretation and reproduction of results (11). Additionally, the four criteria used to select the best equations are added in a way that would guarantee its use and application through simple manual calculations.

CONCLUSIONS

We conclude that through the three developed equations, it is possible to estimate BF% in young volleyball players based on tricipital, subscapular, iliac crest, front thigh, and medial calf skinfolds. Hence, the results suggest that the use and application of the equations are a good alternative method to analyze body composition of young volleyball players in training programs and situations related to health, fitness, and sports.

Address for correspondence: Marco Cossio Bolaños, PhD, Department of Physical Activity Sciences, Catholic University of Maule, Talca, Chile. Av. San Miguel s/n, Talca, Chile. Email: mcossio1972@hotmail.com

REFERENCES

1. Bentzur KM, Kravitz L, Lockner DW. Evaluation of the BOD POD for estimating percent body fat in collegiate track and field female athletes: A comparison of four methods. ***J Strength Cond Res.*** 2008;22(6):1985-1991.

2. Cameron N, Griffiths PL, Wright MM, Blencowe C, Davis NC, Pettifor JM, Norris SA. Regression equations to estimate percentage body fat in African prepubertal children aged 9 y. ***Am J Clin Nutr.*** 2004;80:70-75.

3. Duncan MJ, Woodfield L, Al-Nakeeb Y. Anthropometric and physiological characteristics of junior elite volleyball players. ***Br J Sports Med.*** 2006;40:649-651.

4. Esco MR, Williford WN, Russell AR. Cross-validation of BMI-based equations for predicting percent body fat in female collegiate athletes. ***JEPonline***. 2011;14(3):43-52.

5. Eston RG, Rowlands AV, Charlesworth S, Davies A, Hoppitt, T. Prediction of DXA-determined whole body fat from skinfolds: Importance of including skinfolds from the thigh and calf in young, healthy men and women. ***Eur J Clin Nutr.*** 2005;59:695-702.

6. Fornetti WC, Pivarnik JM, Foley JM, Fiechtner JJ. Reliability and validity of body composition measures in female athletes. ***J Appl Physiol.*** 1999;87(3):1114–1122.

7. Gabbett T, Georgieff B. Physiological and anthropometric characteristics of junior national, state, and novice volleyball players. ***J Strength Cond Res.*** 2007;21(3):902-908.

8. Gartner A, Dioum A, Delpeuch F, Maire B, Schutz Y. Use of hand-to-hand impedancemetry to predict body composition of African women as measured by air displacement plethysmography. ***Eur J Clin Nutr.*** 2004;58:523-531.

9. Gonçalves EM, Silva AM, Matias CN, Lemos-Marini SH, Santos AO, Guerra-Júnior G. Estimation of percent body fat based on anthropometric measurements in children and adolescents with congenital adrenal hyperplasia due to 21-hydroxylase deficiency. ***Clin Nutr.*** 2013;32:45-50.

10. Goran MI, Driscoll P, Johnson R, Nagy TR, Hunter G. Cross-calibration of body-composition techniques against dual-energy X-ray absorptiometry in young children. ***Am J Clin Nutr.*** 1996;63:299-305.

11. Goto R, Mascie-Taylor NCG. Precision of measurement as a component of human variation. ***J Physiol Anthropol.*** 2007;26:253-256.

12. Gualdi-Russo E, Zaccagni L. Somatotype, role and performance in elite volleyball players. ***J Sports Med Phys Fitness.*** 2001;41:256-262.

13. Guo SS, Chumlea WC, Cockram DB. Use of statistical methods to estimate body composition. ***Am J Clin Nutr.*** 1996;64(3):428Se35S.

14. Heyward VH, Wagner DR. ***Applied Body Composition Assessment***. (2nd Edition). Champaign, IL: Human Kinetics, 2004.

15. International Society For the Advancement of Kinanthropometry (ISAK). ***International Standards For Anthropometic Assessment.*** Nueva Zelanda, 2001.

16. Jackson AS, Pollock ML. Generalized equations for predicting body density in men. ***Br J Nutr.*** 1978;40:497-504.

17. Lohman TG. Dual energy X-ray absorptiometry. In: ***Human Body Composition.*** (Editors). AF Roche, SB Heymsfield, TG Lohman, pp. 63-78. Champaign, IL: Human Kinetics, 1996.

18. Marqués MC, Tillaar R, Gabbett TJ, Reis VM, González-Badillo JJ. Physical fitness qualities of professional volleyball players: Determination of positional differences. ***J Strength Cond Res.*** 2009;23(4):1106-1111.

19. Moon JR, Tobkin SE, Smith AE, Lockwood CM, Walter AA, Cramer JT, Beck TW, Stout JR. Anthropometic estimations of percent body fat in NCAA Division I female athletes: A 4-compartment model validation. ***J Strength Cond Res.*** 2009;23:1068-1076.

20. Oliver JM, Lambert BS, Martin SE, Green JS, Crouse SF. Predicting football players' dual-energy x-ray absorptiometry body composition using standard anthropometric Measures. ***J Athl Train.*** 2012;47(3):257-263.

21. Peña J, Guerra JR, Buscà B, Serra N. Which skills and factors better predict winning and losing in high-level men's volleyball? ***J Strength Cond Res.*** 2013;27:487-493.

22. Reilly T, George K, Marfell-Jones M, Scott M, Sutton L, Wallace JA. How well do skinfold equations predict percent body fat in elite soccer players? ***Inter J Sports Med.*** 2009;30:607-613.

23. Sheppard JM, Cronin JB, Gabbet TJ, Mcguigan MR, Etxebarria N, Newton RU. Relative importance of strength power, and anthropometric measures to jump performance of elite volleyball players. ***J Strength Cond Res.*** 2008;22:3:758-765.

24. Silva AM, Minderico SC, Teixeira PJ, Pietrobelli A, Sardinha LB. Body fat measurement in adolescent athletes: Multicompartment molecular model comparison. ***Eur J Clin Nutr.*** 2006;60:955-964.

25. Smith DJ, Roberts D, Watson B. Physical, physiological and performance differences between Canadian national team and university volleyball players. ***J Sports Sci.*** 1992;10(2):131-138.

26. Stevens J, Cai J, Truesdale CP, Cuttler L, Robinson TN, Roberts AL. Percent body fat prediction equations for 8- to 17-year-old American children. ***Pediatr Obes.*** 2013; 9:260-271.

27. Stewart AD, Hannan BW. Prediction of fat and fat-free mass in male athletes using dual X-ray absorptiometry as the reference method. ***J Sports Sci.*** 2000;18(4):263-274.

28. Warner ER, Fornetti WC, Jallo JJ, Pivarnik JM. A skinfold model to predict fat-free mass in female athletes. ***J Athl Train.*** 2004;39(3):259-262.

29. Withers RT, Craig NP, Bourdon PC, Norton KI. Relative body fat and anthropometric prediction of body density of male athletes. ***Eur J Appl Physiol.*** 1987;56:191-200.

30. Yavari R, McEntee E, McEntee M, Brines M. Anthropometric variables accurately predict dual energy x-ray absorptiometric-derived body composition and can be used to screen for diabetes. ***PLoS ONE.*** 2011;6:e24017.