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Association between sports participation, motor competence and weight status: A longitudinal study

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ABSTRACT

Objectives: The aim of this study was to investigate if baseline motor competence, weight status and sports participation in early childhood predict sports participation two years later.
Design: longitudinal study.
Methods: In 2010, motor competence (object control and locomotor skills), weight status and sports participation were assessed in 292 children between three and five years-of-age. In 2012, sports participation was re-evaluated in 206 of the original 292 children. Logistic regression was implemented to examine if initial sports participation, motor competence and weight status would predict sports participation two years later.
Results: In the final model, sports participation in 2010 (OR = 9.68, CI: 3.46 to 27.13) and locomotor skills (OR = 1.21, CI: 1.01 to 1.46) significantly predicted sports participation after two years.
Conclusions: These results suggest that initial sports participation and more advanced locomotor skills in preschool years may be important to promote continued participation in sports across childhood.

1. Introduction

Physical activity (PA) in childhood plays a crucial role in the physical and psychological health of children and throughout the lifespan. During childhood, sports participation (SP) is suggested to be a worthwhile strategy to promote PA[1] and may help alleviate negative obesity and physical inactivity trends.[2,3] The development of motor competence (MC), specifically proficiency in fundamental motor skills (e.g., jumping, throwing, kicking, running striking), is important for successful participation in many sports. Higher levels of MC augment children's success in sports and promote continued participation.[4] Several studies indicate that SP is significantly associated with increased PA,[1] MC,[5,6] general fitness levels[7] and is inversely associated with body fat.[3] However, it is not yet fully understood how SP in youth could be optimized to facilitate continued participation and increased PA.

Cross-sectional studies[6,8] have shown that children who regularly participate in sports demonstrate higher MC than children who do not regularly participate in sports. However, only two studies have investigated longitudinal associations between MC and SP,[7,9] with no studies addressing preschool-aged children. Vandorpe et al.[9] showed that both MC and SP in 6–8 year-old children positively predicted the SP after two years. In addition, Fransen et al.[7] showed that 6–10 year-old children with the highest level of MC had spent more time in club-level SP and had better physical fitness than children with lower MC. Although these studies have assessed children from middle childhood, early childhood (i.e., 2–5 yrs) is particularly critical time for the development of healthy behaviors[10] and this is an optimal time to promote the acquisition of a wide range of motor skills.[11,12]

As young children generally develop locomotor skills earlier than object control skills[13], the development of locomotor skills may be more influential for SP and for promoting healthy behaviors in early childhood.[14] However, current literature does not provide a clear answer. Some studies have shown that locomotor skills are more strongly associated with PA than object control skills in childhood,[14,15] while others studies have shown that object control skills in childhood, but not locomotor skills, predict PA and fitness in adolescence.[16–18] As weight status (WS) is inversely associated with MC across childhood, with the strength of association

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increasing across time,[19] WS also may have an influence on SP across early childhood into middle childhood. Thus, demonstrating low MC and being overweight/obese may decrease adherence to SP.

Based on results of previous literature, the potential impact of developing MC on SP may be important for promoting long-term health-enhancing PA across childhood. However, associations between different categories of MC and SP, specifically in early childhood, have not been investigated. As it is becoming increasingly clear that the development of health-enhancing PA behavior habits (e.g., SP) are established in early childhood, it is important to understand the mechanisms that promote these healthy behaviors. The aim of this study was to investigate if baseline motor competence, weight status and sports participation in early childhood predict sports participation two years later.

2. Methods

In 2010, 292 children (158 boys) aged between three and five years were assessed for MC, weight status and SP. In 2012, 206 children (115 boys) from the baseline group of participants (70.55%, $n = 206/292$) were identified and re-evaluated for SP.

Children were recruited from the Observational Longitudinal Study on Health and Welfare of Preschool Children (*Estudo Longitudinal de Observação da Saúde e Bem-estar da Criança em Idade Pré-escolar*, *ELOS-Pré*), which evaluated different aspects of health in preschoolers such as PA, sedentary behavior and MC. In this longitudinal study, 28 schools proportionally distributed in six political administrative regions of northeastern Brazil were randomly selected. In the sampling process, all regularly enrolled children in each selected school were invited to participate in the study. All study protocols were approved by the local Ethics Committee and written informed consent was obtained from each child's parents or guardians prior to collection of data. All children were assessed between August and December in 2010 for SP, MC and WS, and revaluated at same period in 2012 for SP.

Information about SP was obtained through a questionnaire developed by researchers of the study and answered by parents. In this questionnaire, the parents or guardians answered whether children did or did not participate in organized physical activities (e.g., sports, dance and martial arts). Organized physical activities were activities that involved regular classes, training, or competition; were structured or formal, and had a coach, instructor, or teacher.[20] The child was included in the SP group if they participated in organized physical activities for at least 1 h per week as part of a supervised activity.

Motor competence was assessed with the Test of Gross Motor Development—Second Edition (TGMD-2).[21] The TGMD-2 is a valid and reliable test for Brazilian children and evaluates the performance of six locomotor and six object control skills.[21] Each skill includes 3–5 performance criteria that are scored as present (1 point) or absent (0 point) using process-oriented checklists. The score obtained in two attempts at each skill was summed to give a raw score of the locomotion (0–48 points) and object control (0–48 points) subscales. The scores of each subscale were then transformed into standard score for analysis. All trials for every skill were assessed independently by two trained raters. After that, all rater disagreements were reassessed by both raters together to define the final value (0 or 1). Thus, there was a final agreement of 100% between raters. The initial inter-rater agreement[22] was strong for both the locomotor skills (ICC = .93, 95%CI .90 to .96) and for the object control skills (ICC = .87, 95%CI .81 to .92). The intra-rater agreement for locomotor skills (ICC = .97, 95% CI .95 to .98) and object control skills (ICC = .95, 95%CI .92 to .97) was also strong.

Body mass index (BMI) was calculated by dividing body mass (kg) by stature squared (m^2). Stature was measured with a portable stadiometer/scale to the nearest .1 cm. Body mass was measured with a portable scale to the nearest .1 kg. Children were classified as normal weight, overweight and obese according to gender and age-specific BMI cutoff values proposed by the International Obesity Task Force (IOTF).[23] Subsequently, overweight and obese subjects were grouped into an 'unhealthy weight' cohort.

Participant's descriptive information is provided in Table 1. Logistic regression was conducted in order to investigate if baseline motor competence, weight status and sports participation in early childhood would predict sports participation two years later. The unadjusted analysis evaluated the association between each predictor from baseline with SP after two years as the outcome variable. Using a backward method, all variables were considered in the adjusted analysis and those that had $p < .20$ or contributed to the model fit index were retained for the regression models (1, 2 and 3).[24] Age, gender and socioeconomic status (SES) were used as adjustment. The SES information was obtained from the questionnaire of the study with the minimum wage set at 300 dollars per month. Accordingly, participants were grouped as follows: low SES (family income is <2× minimum wage), medium (family income between 2 and 4× minimum wage) and high (family income >4× minimum wage). Model fit was assessed using the Hosmer and Lemeshow test. The goodness-of-fit test was considered satisfactory when the Hosmer and Lemeshow test was greater than .70 (range: .00–1.00).[24] The Cox and Snell R^2 and Nagelkerke R^2 were also used as an indicator of model appropriateness. The magnitudes of the associations were expressed as Odds Ratios (OR) and their respective confidence intervals (95%CI). All analyses were performed using STATA 11.0 and SPSS 17.0 with significance level for variables in the final model set at $p < .05$.

3. Results

Descriptive statistics for age, stature, body mass, BMI and MC are shown in Table 1. Of the 206 children who had data from both baseline and after two years, 24 children (11.65%) in baseline and 52 children after two years (25.24%) participated in sports. Seventeen children among those who participated in sports in baseline still participated in sports in 2012 (70.83%).

In total, 15.05% were overweight and 9.71% were obese, totalizing 24.76% of children classified in the unhealthy weight cohort. Regarding SES, 58 children were classified as low, 109 as medium, and 39 as high income.

Table 2 shows the results from unadjusted and adjusted analyzes (Models 1, 2 and 3). Logistic regression results indicated object control skills were not associated with SP after two years in both the unadjusted and adjusted model (Model 1). Therefore, object control skills were excluded from further analyses.[24] In Model 1, SP at baseline and locomotor skills were significant predictors, but model fit was not strong ($\chi^2 = 5.68$; $p = .68$). In Model 2, the withdrawal of WS did not affect the significance of the predictors and the fit of this model was not better than Model 1 ($\chi^2 = 6.05$; $p = .53$). During the modeling, WS was regarded as predictor and all possible adjustment variables were tested. Model 3 (without gender adjustment variable) achieved a strong fit[24] ($\chi^2 = .48$; $p = 1.00$) and was chosen as the best adjusted model based on the data. As gender was not a significant predictor in the model, the exclusion of gender did not affect the impact of the variables and significantly improved model fit. Thus, SP and locomotor skills at baseline were associated with SP after two years (Table 2, Model 3). Participation in sports at baseline was the strongest predictor of SP after two years (OR = 9.68). In addition, each one-point increase in locomotor skills represented an increase of approximately 21% probability of

Table 1
Descriptive statistics (Mean ± SD) of age, stature, body mass, BMI and motor competence for the dropout and test sample.

Variables	Test sample				Dropout sample				
	Boys (n = 115)	Girls (n = 91)	F	Total (n = 206)	Boys (n = 42)	Girls (n = 44)	F	Total (n = 86)	F (total)
Age 2010 (months)	57.39 ± 10.21	58.56 ± 8.06	.80	57.91 ± 9.33	57.32 ± 11.00	55.19 ± 8.84	.98	56.23 ± 9.95	1.89
Age 2012 (months)	81.78 ± 10.23	82.92 ± 8.08	.76	82.29 ± 9.33					
Stature (m)	1.09 ± .75	1.09 ± .72	.55	1.09 ± .73	1.09 ± .81	1.08 ± .82	.01	1.08 ± .81	.01
Body mass (kg)	19.39 ± 4.96	19.56 ± 4.77	.01	19.47 ± 4.87	18.35 ± 3.13	19.79 ± 4.20	3.23	18.94 ± 3.78	.81
BMI (kg/m^2)	16.01 ± 2.42	16.24 ± 2.65	.46	16.11 ± 2.52	16.27 ± 1.55	16.82 ± 2.61	1.40	16.07 ± 2.29	.02
Locomotor skills (SS)	10.16 ± 2.09	9.96 ± 1.76	2.36	10.07 ± 1.95	10.39 ± 2.17	10.58 ± 2.01	.18	10.49 ± 2.08	2.71
Object control skills (SS)	9.43 ± 2.35	8.96 ± 2.06	2.26	9.34 ± 2.25	9.76 ± 1.88	10.53 ± 2.00	3.38	9.75 ± 1.97	2.16

Note, BMI, body mass index; SS, standard score.

Table 2
Logistic regression results for the association between sports participation, motor competence, weight status at baseline and sports participation two years later (Models 1, 2 and 3).

Variables	Unadjusted				Model 1*				Model 2**				Model 3***			
	OR	LCI	HCI	p	OR	LCI	HCI	p	OR	LCI	HCI	p	OR	LCI	HCI	p
SP at baseline																
No	1.00			<.01	1.00			<.01	1.00			<.01	**1.00**			**<.01**
Yes	10.20	3.93	26.49		9.68	3.45	27.11		9.64	3.45	26.90		**9.68**	**3.46**	**27.13**	
Locomotor skills	1.18	1.01	1.39	.04	1.22	1.01	1.47	.03	1.19	1.01	1.44	.04	**1.21**	**1.01**	**1.46**	**.03**
Object control skills	1.04	.90	1.20	.59	Excluded				Excluded				Excluded			
Weight status									Excluded							
Unhealthy weight	1.00			.25	1.00			.28					1.00			.28
Normal weight	.66	.33	1.33		.65	.30	1.42						.65	.29	1.42	

Note, LCI, lower confidence interval; OR, odds ratio; SP, sports participation; UCI, upper confidence interval.
* Adjusted for age, gender and socioeconomic status (χ^2 = 5.68; p = .68).
** Adjusted for age, gender and socioeconomic status (χ^2 = 6.05; p = .53)
*** Adjusted for age and socioeconomic status (χ^2 = .48; p = 1.00).

participating in sports after two years. Weight status was not a significant predictor of SP, but it was important for the model fit. The variables of the Model 3 explained between 14.5% (Cox and Snell R^2) and 21.4% (Nagelkerke R^2) of the variance in SP after two years.

4. Discussion

The aim of this study was to investigate if baseline motor competence, weight status and sports participation in early childhood predict sports participation two years later. Overall, previous SP was the strongest factor for predicting future SP in this sample. The present study also seems to partially confirm the influence of MC on continued SP through locomotor skill development. Preschoolers who initially participated in sports and demonstrated more advanced locomotor skills and were more likely to participate in sports two years later.

As the development of MC is a cumulative and relatively permanent phenomenon (in contrast to dietary habits or PA level), its effects on SP, and associated PA may be persistent across childhood and throughout lifespan. The promotion of context-specific physical activities (e.g., SP) in early childhood also is suggested to initially promote the development of MC.[4,25] Thus, participation in sports early in childhood also may be critical to establish both MC and PA habits. Overall, a reciprocal mechanism of interaction[26] is suggested to promote a sustained positive spiral of engagement in PA, which includes SP activities.[4,25]

The fact that a positive association between MC at baseline and SP in middle childhood is only apparent for locomotion skills may be related to a control hierarchy of fundamental motor skill development.[13] Locomotor skills are the first subset of MC to be associated with SP as it involves independent upright locomotion. The next step in the hierarchy is the development of object control skills, which are also generally associated with the maintenance of posture.[13] Because more complex perceptual-motor adjustments are needed for controlled and precise object manipulation and projection, it is clear that prolonged exposure to motor experiences involving object control skills may be needed to achieve mastery in this area.[13]

Aligned with results of previous studies with older children,[5–7] the present longitudinal data also found an association between SP and MC, therefore broadening the findings to younger children. Such results are particularly important considering that early childhood in an optimal time frame for experiencing and developing motor actions.[12] In early childhood it is hypothesized that the nervous system might be more sensitive to learning processes that produce permanent and definitive changes in certain neural structures.[11] Moreover, early childhood is considered critical for the development of health-related behaviors that tend to perpetuate themselves in later stages of life.[10]

Another difference between the previously mentioned studies and the current study on the association between MC and SP may be attributed to the assessment of MC that was used. Vandorpe et al.[9] and Fransen et al.[7] evaluated gross motor coordination via a product-oriented assessment (Körperkoordinationstest für Kinder–KTK). One of the main difficulties of this type of measure is that skill outcomes do not necessarily highlight the developmental process (i.e., qualitative movement pattern development) that results in the achieved score. Furthermore, some scores of the KTK test may be negatively influenced by excess body mass because the KTK subtests require the support and/or transport of body mass.[27] In the present study, MC was evaluated through a process-oriented approach, which can be particularly important in younger ages to measure MC.[12]

Among the 24 preschoolers who participated in sports at baseline, 17 of them (71%) continued to participate after two years. One possible explanation for the persistence in SP may be the synergistic relationship between MC and engagement in physical activities and sports.[4,25] Children with advanced MC may be more successful in structured activities and, as a result, have a more positive experience and have more fun than individuals whose MC level may limit their participation or engagement. Theoretically, children who have the opportunity to participate in organized sports at a very young age also have more opportunities to practice and develop their MC. In the present study, children with more advanced locomotor skills at baseline were 21% more likely to participate in sports two years later, suggesting that MC is a key factor for continued engagement in sports.

However, parental influences and other family-related factors such as cost, distance to travel and time commitments can influence parents' decisions about their child's participation in sports. The choice of parents to allow their children to participate in structured activities is one factor that was not accounted for in this study. Although the present study did not assess the parental influence and the children's perceptions of MC, children who considered themselves as competent may be more likely to participate in physical and sports activities and therefore continue to be physically active in sports and during their leisure time. Weiss[28] suggests the main reasons for the involvement in physical activities and sports in children and adolescents are: (a) the development and demonstration of physical competence (e.g., learn and improve skills), (b) achieving acceptance and social support (e.g. being with and making friends; being reinforced by parents and coaches) and (c) experiencing enjoyment (e.g., having fun and challenging oneself). It is also reasonable to assume that when participating in a particular sport, children with higher levels of MC may feel more motivated to sustain their participation.[28] Hence, they have a higher chance of movement success which might result in further ongoing participation as described in the positive cycle of engagement in PA.[24] In addition, children who are given the opportunity to participate in organized sports at a very young age also have more opportunities to practice and develop their MC.

Rationale for the lack of an association of WS with both MC and SP remains uncertain, but one possible explanation may be related to the age of the participants. A recent systematic review showed a weak inverse relationship between MC and WS in early childhood,[19] but the strength of associations between MC and WS increases across childhood and adolescence.[19,25] So it may be that WS, especially in younger children, has less influence on SP, but becomes increasingly important later in the developmental process.[19,25]

While this is the first study to longitudinally investigate the influence of SP, MC and WS at preschool age on SP in middle childhood, some limitations should be considered. The lack of statistical power might have influenced non-significant associations, particularly for WS. Moreover, MC was not measured during the follow up, which would provide important information on the continued development of MC across time. Another limitation was the dropout rate between measurements. Despite the sample loss, subjects who left the study did not differ from included participants ($p > .05$) in their baseline assessment (Table 1). This would suggest selection bias was not a factor in the final sample. With regard to the influence of the environment and parents on SP, it must be recognized that the decisions or beliefs of parents can influence SP in young children. Also, the content of the lessons, as well as learning variables (e.g., feedback, distribution of practice etc.) are important aspects of SP that need to be addressed in future studies to better understand the potential reciprocal influence of SP and MC on each other.

Future studies should also investigate the association between MC and the type of sport practiced because relationships between SP and MC may be different depending on the nature of the sport.[29,30] In addition, understanding the potential differential effects of MC specificity, as locomotor, object control and balance skills may be differently associated with SP across childhood.[15–18,29] Such information might enhance our understanding about sustained SP across childhood.

5. Conclusion

The results of this study indicate that early participation in sport and more advanced locomotor skills in early childhood are important to promote future SP. Our results also partially support the theoretical model proposed by Stodden et al.[25] suggesting that early involvement in physical activities such as SP and higher MC promote a positive spiral of engagement in physical activities. As locomotor skills develop earlier than object control skills, they may be important requisites of future SP across childhood. It is recommended that all children, especially those with delayed locomotor skills, should be provided developmentally appropriate opportunities to promote the acquisition of fundamental motor skills early in childhood. As such, continued engagement in SP might provide an optimal environment for continued development of MC that provides a basis for lifetime engagement in a variety of health-enhancing PA and sports in the future.

Practical implications

- Sports participation in early childhood significantly enhances the probability for continued participation in sports across childhood.
- Advanced locomotor skills in early childhood may be important for sustained SP.
- Providing opportunities for participation in sports and the development of motor skills can stimulate SP across childhood, which may promote positive and sustainable trajectories of health-enhancing behaviors.
- These findings provide rationale for physical education teachers and youth sport coaches to improve curricula for children's physical education.

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References

1. Wickel EE, Eisenmann JC. Contribution of youth sport to total daily physical activity among 6- to 12-yr-old boys. *Med Sci Sports Exerc* 2007; 39(9): 1493–1500.
2. Malina RM. Children and adolescents in the sport culture: the overwhelming majority to the select few. *J Exerc Sci Fit* 2009; 7(2):1–10.
3. Basterfield L, Reilly JK, Pearce MS et al. Longitudinal associations between sports participation, body composition and physical activity from childhood to adolescence. *J Sci Med Sport* 2014; 18(2):178–182.
4. Robinson LE, Stodden DF, Barnett LM et al. Motor competence and its effect on positive developmental trajectories of health. *Sports Med* 2015, http://dx.doi.org/10.1007/s40279-015-0351-6.
5. D'Hondt E, Deforche B, Gentier I et al. A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. *Int J Obes* 2013; 37(1):61–67.
6. Queiroz DR, Ré AHN, Henrique RS et al. Participation in sports practice and motor competence in preschoolers. *Motriz* 2014; 20(1):26–32.

7. Fransen J, Deprez D, Pion J et al. Changes in physical fitness and sports participation among children with different levels of motor competence: a 2-year longitudinal study. *Pediatr Exerc Sci* 2014; 26(1):11–21.
8. Graf C, Koch B, Kretschmann-Kandel E et al. Correlation between BMI, leisure habits and motor abilities in childhood (CHILT-project). *Int J Obes Relat Metab Disord* 2004; 28(1):22–26.
9. Vandorpe B, Vandendriessche J, Vaeyens R et al. Relationship between sports participation and the level of motor coordination in childhood: a longitudinal approach. *J Sci Med Sport* 2012; 15(3):220–225.
10. Timmons BW, Leblanc AG, Carson V et al. Systematic review of physical activity and health in the early years (aged 0–4 years). *Appl Physiol Nutr Metab* 2012; 37(4):773–792.
11. Gabbard C. *Lifelong motor development*, 5th ed. San Francisco, CA, Pearson Benjamin Cummings, 2008.
12. Hardy LL, King L, Farrell L et al. Fundamental movement skills among Australian preschool children. *J Sci Med Sport* 2010; 13(5):503–508.
13. Gallahue D, Donnelly F. *Developmental physical education for all children*, 4th ed. Champaign, IL, Human Kinetics, 2003.
14. Williams HG, Pfeiffer KA, O'Neill JR et al. Motor skill performance and physical activity in preschool children. *Obesity* 2008; 16(6):1421–1426.
15. Hamstra-Wright KL, Swanik CB, Sitler MR et al. Gender comparisons of dynamic restraint and motor skill in children. *Clin J Sport Med* 2006; 16(1):56–62.
16. Barnett LM, Morgan PJ, Van Beurden E et al. Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. *Int J Behav Nutr Phys Act* 2008; 5:40.
17. Barnett LM, Morgan PJ, Van Beurden E et al. A reverse pathway? Actual and perceived skill proficiency and physical activity. *Med Sci Sports Exerc* 2011; 43(5):898–904.
18. Stodden DF, Gao Z, Goodway JD et al. Dynamic relationships between motor skill competence and health-related fitness in youth. *Pediatr Exerc Sci* 2014; 26(3):231–241.
19. Cattuzzo MT, Henrique RS, Ré AHN et al. Motor competence and health related physical fitness in youth: a systematic review. *J Sci Med Sport* 2014, http://dx.doi.org/10.1016/j.jsams.2014.12.004.
20. Okely AD, Booth ML, Patterson JW. Relationship of physical activity to fundamental movement skills among adolescents. *Med Sci Sports Exerc* 2001; 33(11):1899–1904.
21. Ulrich DA. *Test of gross motor development*, 2nd ed. Austin, TX, PRO-ED, 2000.
22. Stephen JW. *Quality of life outcomes in clinical trials and health-care evaluation: a practical guide to analysis and interpretation*, London, England, Antony Rowe, 2009.
23. Cole TJ, Bellizzi MC, Flegal KM et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000; 320(7244):1240–1246.
24. Hosmer DW, Lemeshow S. *Applied logistic regression*, 2nd ed. New York, NY, Wiley, 2000.
25. Stodden DF, Goodway JD, Langendorfer SJ et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. *Quest* 2008; 60(2):290–306.
26. Bertalanffy LV. The theory of open systems in physics and biology. *Science* 1950; 111(2872):23–29.
27. D'Hondt E, Deforche B, De Bourdeaudhuij I et al. Relationship between motor skill and body mass index in 5- to 10-year-old children. *Adapt Phys Activ Q* 2009; 26(1):21–37.
28. Weiss MR. Back to the future: research trends in youth motivation and physical activity. *Pediatr Exerc Sci* 2013; 25(4):561–572.
29. Hulteen RM, Lander NJ, Morgan PJ et al. Validity and reliability of field-based measures for assessing movement skill competency in lifelong physical activities: a systematic review. *Sports Med* 2015, http://dx.doi.org/10.1007/s40279-015-0357-0.
30. Barnett L, Hinkley T, Okely AD et al. Child, family and environmental correlates of children's motor skill proficiency. *J Sci Med Sport* 2013; 16(4):332–336.