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Association between physical activity and health-related quality of life in elderly individuals with pre-diabetes in rural Hunan Province, China: a cross-sectional study

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ABSTRACT

Objectives There are few data on the relationship between health-related quality of life (HRQoL) and physical activity among elderly individuals with pre-diabetes. This study aimed to determine if differences existed in HRQoL between individuals with pre-diabetes who were physically active compared with those who were physically inactive in rural China.

Design, setting and participants A cross-sectional survey was conducted among the elderly (≧60 years) in rural communities in Yiyang City of China. Multistage cluster random sampling was carried out to select 42 areas, and interviews were conducted among 434 elderly individuals with pre-diabetes. Pre-diabetes was screened using an oral glucose tolerance test.

Main outcome measures The Medical Outcomes Study 36-Item Short Form Health Survey questionnaire was used to measure HRQoL. Physical activity was assessed using the International Physical Activity Questionnaire. Multivariate analysis of covariance (MANCOVA) was used to test for differences in HRQoL between the physically active group and the inactive group.

Results A total of 434 individuals with pre-diabetes were included in this study. The physical component summary (PCS) score of HRQoL was 42.1±10.2 and the mental component summary score was 46.4±8.9. A median total physical activity of 524 metabolic equivalent-min/week was reported. A significant MANCOVA model (Wilks' λ=0.962, $F(2,423)$=8.44, P<0.001) indicated that elderly individuals with pre-diabetes who were physically active reported higher PCS scores (M_{diff}=5.2, P<0.001, effective size=0.47) compared with those physically inactive after adjusting for the following covariates: age, gender, marital status, education, smoking, chronic disease, body mass index and waist:hip ratio.

Conclusions The HRQoL of elderly individuals with pre-diabetes is poor in rural China. These findings demonstrated that elderly individuals with pre-diabetes who were physically active had higher PCS scores than those who were physically inactive. Furthermore, these results support the rationale for developing a physical activity intervention for HRQoL of individuals with pre-diabetes.

Trial registration number ChiCTR-IOR-15007033; Results.

Strengths and limitations of this study

- This is the first study to examine the association between health-related quality of life (HRQoL) and physical activity among elderly individuals with pre-diabetes in rural China.
- The association between HRQoL and physical activity is analysed both from the physical component summary score and the mental component summary score, making the results more accurate and comprehensive.
- The International Physical Activity Questionnaire-long version and the Medical Outcomes Study 36-item Short Form Health Survey questionnaire are proven to be suitable for assessment in the elderly (≧60 years) in China, making the results of the study generalisable.
- The cross-sectional study design makes causal relationships indeterminable.
- The study is limited by its self-reported design.

INTRODUCTION

Pre-diabetes describes individuals who have impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT).[1] Many studies have identified that people with pre-diabetes have a high risk of developing diabetes, and the occurrence increases with age.[2 3] In China, it has been estimated that more than 148.2 million adults have pre-diabetes and more than 20% of the elderly have pre-diabetes, both in rural and urban areas.[4] However, several trials have demonstrated that pre-diabetes can be inverted to normal plasma glucose levels, and that the risk of developing diabetes decreases after a diet and physical activity lifestyle intervention.[5 6]

Health-related quality of life (HRQoL) is a comprehensive and multidimensional condition that includes physical, emotional and social functions.[7 8] Many studies have found that both sociodemographic and lifestyle factors are related to HRQoL.[9–11] Studies also found that the HRQoL scores were relatively lower among individuals with IGT compared with the healthy population; besides, individuals progressing to pre-diabetes or diabetes experienced a greater loss in HRQoL than people with persistent normal glucose tolerance.[12–14] Thus, assessing the HRQoL enables us to investigate its influencing factors, and consequently create interventions to improve it, especially by relieving pain, malaise and consequences of diseases.[15 16]

Several studies have shown that active physical activity had a positive effect on both the physical and mental domains of HRQoL among patients with diabetes and the elderly.[17–19] A systematic review demonstrated a positive association between physical activity and HRQoL in a general adult population.[20] Many studies have reported that physical activity intervention can significantly improve the quality of life in clinical and healthy populations.[21–23] Furthermore, a study reported higher scores on HRQoL in overweight and obese individuals who were in an action stage of change for exercise compared with those in a precontemplation stage.[24] However, there are few studies in the literature that have evaluated the influence of physical activity on HRQoL among elderly individuals with pre-diabetes. Moreover, there is still a paucity of published studies on HRQoL among elderly individuals with pre-diabetes in rural areas in China.

Therefore, the aim of our study was to investigate the situation of HRQoL and physical activity among the elderly with pre-diabetes in rural areas. Moreover, we intended to explore the association between physical activity and HRQoL. We hypothesised that elderly individuals with pre-diabetes who were physically active would report higher HRQoL scores than those who were physically inactive.

METHODS

Study design

This was a cross-sectional study that was carried out in the rural areas of Yiyang City of Hunan Province in China between April and July 2015. This study was registered at the Chinese Clinical Trial Registry (trial registration number: ChiCTR-IOR-15007033). All participants signed the respective consent forms.

Sample size

Sample size was calculated using the formula for cross-sectional studies as follows:

$$N = \frac{Z^2_{1-\alpha/2}\, p(1-p)}{d^2}$$

where $Z_{1-\alpha/2}$=1.96 when α=0.05, p is the prevalence of pre-diabetes (which was 20% in this study), and d is admissible error (which was 4% here). According to the formula, the theoretical sample size was 423, which included an extra 10% to allow for subjects lost during the study. Our initial investigation revealed there were about 10 elderly subjects with pre-diabetes in each village, so a total of 42 villages were required.

Study population and procedures

The subjects in this study were aged 60 years and over and were from the rural areas of Yiyang City of Hunan Province. To select a representative sample of elderly population with pre-diabetes, a screening programme was carried out in the elderly population in Yiyang City. A multistage cluster randomised sampling method was used. In the first stage, two out of six counties were selected according to geographical characteristics. In the second stage, 2 (Yangluozhou and Yinfengqiao) out of 11 townships and 2 (Qingshuzui and Maocaojie) out of 9 townships were randomly selected. In the third stage, 25% of the rural villages were randomly selected from each chosen township (each township contains 30–50 villages). In the final stage, all households in each selected village with elderly individuals who had lived in the area for 3 years or longer were eligible to participate in the screening programme. Those with severe physical and mental illness were excluded from the screening. Participants diagnosed as having pre-diabetes using oral glucose tolerance test (OGTT) were enrolled in this study. After overnight fasting of at least 10 hours and no breakfast, the participant's venous blood was sampled into a vacuum tube and stored at −80°C for no more than 1 hour to analyse fasting blood glucose. Next, each participant consumed a standard 75 g glucose solution and the venous blood was sampled again 2 hours later to measure the 2-hour postglucose load. The level of plasma glucose was measured using the hexokinase enzymatic method. The diagnostic standards for pre-diabetes as stated in the 1999 WHO criteria[1] were applied, and subjects were categorised into the following three groups: (1) an IFG group with fasting plasma glucose of 6.1–7.0 mmol/L and a 2-hour postglucose load of <7.8 mmol/L; (2) an IGT group with a 2-hour postglucose load of 7.8–11.1 mmol/L and fasting plasma glucose of ≤6.1 mmol/L; and (3) an IFG+IGT group.

More details of the study design and the pre-diabetes screening procedure have been described elsewhere.[25] In brief, 2144 elderly individuals took part in the pre-diabetes screening programme and completed the OGTT, and in total 461 elderly individuals had pre-diabetes. For various reasons, 21 of those with pre-diabetes had no response, and the response rate was 95.4%. Six more had incomplete data. Finally, a total of 434 individuals with pre-diabetes from 42 villages were included in this study.

Data collection and measurements

Sociodemographic information

Sociodemographic information was collected by trained staff using a set of structured questionnaires, which included age, gender, marital status, education, history of hyperglycaemia, family history of diabetes, chronic disease, smoking and alcohol drinking. Marital status was classified as married or non-married. Non-married status included divorce, never married, losing a partner and living together without a marriage certificate. Family history of diabetes was defined as being present in subjects whose first-degree relatives were diabetic. Education was assessed by asking the participants to select their highest level of education from the following choices: less than 1 year, 1–6 years and 6 years and above. History of hyperglycaemia was defined as a situation of fasting glucose >6.1 mmol/L or 2-hour glucose >7.8 mmol/L without a diagnosis of diabetes, which was measured in other places before the interview. Smoking was defined as averaging one or more cigarettes in the last year. Alcohol drinking was defined as drinking a glass of wine (approximately 250 mL beer or 100 mL sake or 20 mL liquor). Chronic diseases included hypertension, coronary heart disease, dyslipidaemia and others.

Anthropometric measurements

Anthropometric measurements included height, weight, blood pressure, waist circumference and hip circumference. The standing height of the participants without shoes was measured using a portable stadiometer and recorded to the nearest 0.1 cm. The weight of the participants with light clothing and without shoes was measured to the nearest 0.1 kg using a digital scale. Body mass index (BMI) was calculated using the formula of weight in kilogram divided by height in m^2 (kg/m^2). The current Chinese standard classification states that the cut-off values for normal weight, overweight and obesity BMI are 18.5 kg/m^2, 24.0 kg/m^2 and 28.0 kg/m^2, respectively.[26] Blood pressure included systolic and diastolic pressure and was assessed twice (2 min apart) using an electronic blood pressure monitor (LifeSource UA-767PV, A&D Medical, San Jose, California, USA) after the participant had been seated for at least 5 min in a quiet room. The two blood pressure readings were averaged to use for analysis. Hypertension was defined as systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure ≥90 mm Hg.[27] Hypotension was defined as systolic blood pressure <90 mm Hg and/or diastolic blood pressure <60 mm Hg.[27] Hypertension and hypotension were defined as abnormal blood pressure. Waist circumference was measured to the nearest 0.1 cm by placing a non-stretch measuring tape horizontally around the participant's abdomen at the top of the iliac crest. Hip circumference was assessed at the point of maximum circumference over the buttocks, with the measuring tape held horizontally and touching the surface of light clothing. The waist:hip ratio (WHR) was calculated by dividing the waist circumference by the hip circumference. A WHR >0.9 in men or >0.8 in women was defined as abnormal.[28]

HRQoL assessment

HRQoL was assessed using the Medical Outcomes Study 36-Item Short Form Health Survey (SF-36).[29] The SF-36 health survey questionnaire has been translated and validated in Chinese, and the Chinese version of the SF-36 has been proven to be reliable and valid in an elderly population.[30] The SF-36 has been widely used to compare the quality of life of people with different diseases,[31 32] as well as among people who are disease-free.[33] It contains 36 items grouped into eight main domains that constitute the two main components: physical health component and mental health component. The physical health section includes four parts: physical functioning, role-physical, bodily pain and general health, while vitality, social functioning, role-emotional and mental health are included in the mental health component. The eight domains were scored from 0 to 100 indicating worst to best possible health. All scores were further summarised and standardised into the physical component summary score (PCS) and the mental component summary score (MCS) according to American norms to allow for international comparisons.[34]

Physical activity assessment

The International Physical Activity Questionnaire-long version (IPAQ) was used to assess physical activity. The IPAQ has been translated and validated in different languages, including Chinese, and the Chinese version of the IPAQ has been shown to be an appropriate physical activity assessment in the Chinese population.[35] The IPAQ-long version assesses a subject's physical activity in the last week in four domains with a minimum duration of 10 min per bout. It also identifies the frequency and time spending on three specific intensities of physical activity, namely walking, moderate and vigorous. The metabolic equivalent (MET) values were used for measurements. The patient's total physical activity MET-min/week was calculated by the sum of the walking, moderate and vigorous intensity activity scores. Based on the public health guidelines[36] and recommended thresholds,[37] subjects were categorised as 'active' if they achieved ≥600 MET-min/week (equal to ≥150 min/week of moderate activity) and those who achieved less were considered to be 'inactive'.

Statistical analysis

Descriptive analyses were performed considering absolute frequency and relative percentage. Data were described as n (%) for categorical variables and mean±SD or median (P_{25}–P_{75}) for numerical variables. The mean (±SD) PCS and MCS scores of HRQoL and their 95% CIs were also calculated. The X^2 test for categorical variables and independent sample t-test for normal distribution continuous variables were used to compare the differences between the physically active group and the physically inactive group. The t-test or one-way analysis of variance was used to identify the differences in PCS and MCS scores depending on different independent variables. The Mann-Whitney U test or Kruskal-Wallis test was used to identify the differences in total physical activity score depending on different variables. If necessary, the Nemenyi test for non-normal distribution and the Student-Newman-Keuls method for normal distribution were used to identify differences within groups.

The Spearman's rank correlation coefficient test was done to explore the magnitude and relationships between variables that potentially influenced HRQoL. General linear models of multivariate analysis of covariance (MANCOVA) were used to test differences in HRQoL (ie, PCS and MCS) between the physically active and inactive groups. Physically inactive was coded as 0 and active was coded as 1. Sociodemographic and anthropometric variables were treated as possible covariates. A significant MANCOVA was followed by univariate *F*-tests using the Wilks' λ statistic. Linear independent pairwise comparisons were analysed to examine the magnitude of the difference in the mean scores of the dependent variables. Effect sizes (d) were computed by dividing the difference in means between groups by the pooled SD and were interpreted as small (d=0.20), medium (d=0.50) or large (d=0.80).[38] Analyses in this study were performed by SPSS V.19.0.

RESULTS

Characteristics of study subjects

A total of 461 elderly individuals had pre-diabetes, and the prevalence of pre-diabetes was 21.5% (461/2144). Ultimately, 434 of these individuals were included in this study. The average age of all participants was 69.4±6.4 years. A majority of the subjects were female, married and completed 1–6 years of education. More than 90% of elderly people with pre-diabetes had no history of hyperglycaemia and no family history of diabetes. The average BMI was 23.7±3.6 kg/m^2. Participants reported a mean waist circumference of 84.9±9.4 cm and a mean hip circumference of 92.0±10.4 cm.

According to their IPAQ scores, 252 (58.1%) were physically inactive and 182 (41.9%) were physically active. There were significant differences in chronic disease, BMI, waist circumference and WHR between the physically active and inactive groups. Physically inactive subjects were those who had at least one chronic disease, higher BMI, higher waist circumference and higher WHR (all P<0.05). The descriptive characteristics of elderly subjects with pre-diabetes are shown in table 1.

HRQoL score

Individuals with pre-diabetes reported a mean (±SD) PCS score of 42.1±10.2 and a mean (±SD) MCS score of 46.4±8.9. The means and their 95% CIs for both physical and mental component scores according to sociodemographic and physiological features are shown in table 2. Neither component scores showed a statistical difference for the variables of family history of diabetes, smoking, alcohol drinking or blood pressure (all P>0.05). For the physical component, there were significant statistical differences in age, history of hyperglycaemia, history of chronic disease, BMI and WHR (all P<0.05). The PCS scores were lower among people who were older and had a history of hyperglycaemia, at least one kind of chronic disease, abnormal WHR and higher BMI. For the mental component, there were statistically significant differences in gender, education and marital status (all P<0.05). Individuals who were female, completed more education and were married had higher scores on the mental component of HRQoL.

IPAQ score

The total physical activity scores of individuals with pre-diabetes measured by the IPAQ are shown in table 3. Together, they reported a median total physical activity of 524.0 MET-min/week. Individuals with pre-diabetes who were physically active reported a median total physical activity of 832.5 MET-min/week. Individuals with pre-diabetes who were physically inactive reported a median total physical activity of 120.0 MET-min/week. The total physical activity score was significantly different in terms of gender, history of hyperglycaemia, other chronic disease and smoking through non-parametric tests (all P<0.05). Participants who were male, had no history of hyperglycaemia, no chronic disease and no smoking reported higher total MET values compared with those who were female and had a history of hyperglycaemia, chronic disease and smoking.

Association between physical activity and HRQoL

Correlations between HRQoL, sociodemographics and the health characteristics of individuals with pre-diabetes are presented in table 4. Spearman's correlation coefficients (r) indicated that PCS was significantly correlated with physical activity (r=0.209, P<0.01) and chronic disease (r=−0.133, P<0.01), whereas MCS was significantly correlated with gender (r=0.196, P<0.01). Physical activity was significantly correlated with gender (r=0.112, P<0.05), smoking (r=−0.093, P<0.05) and chronic disease (r=0.134, P<0.01). Variables with significant P values in the correlation analysis and thought to be important influencing factors of HRQoL were entered into the multivariate model.

With HRQoL entered as the dependent variable and physical activity (as a binary variable) entered as the independent variable, the overall multivariate analysis of covariance (MANCOVA) was significant (Wilks' λ=0.956, *F*(2,431)=10.03, P<0.001). Follow-up univariate *F* statistics indicated significant differences only for PCS (*F*=19.49, P<0.001). A linear independent pairwise comparison indicated that those who were physically active reported significantly higher scores on the PCS (M_{diff}=5.6, P<0.001, effective size (ES)=0.55) than those who were physically inactive. After adjusting for the covariates of age, gender, marital status, education, smoking, chronic disease, BMI and WHR, the overall MANCOVA model was significant (Wilks' λ=0.962, *F*(2,423)=8.44, P<0.001). A linear independent pairwise comparison indicated that those who were physically active still reported a significantly higher score in the PCS (M_{diff}=5.2, P<0.001, ES=0.47) than those who were physically inactive. Results are shown in table 5.

DISCUSSION

This study showed a high prevalence (21.5%) of pre-diabetes among the rural elderly, which is similar to the

Table 1 Characteristics of elderly individuals with pre-diabetes

Characteristics	Overall (n=434)	Physically active Yes (n=182)	Physically active No (n=252)	P value
Age (years)	69.4±6.4	68.8±6.1	69.7±6.8	0.182
Gender				
Male	180 (41.5)	84 (46.2)	96 (38.1)	0.093
Female	254 (58.5)	98 (53.8)	156 (61.9)	
Education				
Less than 1 year	81 (18.7)	30 (16.5)	51 (20.2)	0.597
1–6 years	272 (62.6)	118 (64.8)	154 (61.1)	
6 years and above	81 (18.7)	34 (18.7)	47 (18.7)	
Marital status				
Married	312 (71.9)	128 (70.3)	184 (73.4)	0.480
Non-married	122 (28.1)	54 (29.7)	68 (26.6)	
History of hyperglycaemia				
Yes	28 (6.5)	16 (8.8)	12 (4.8)	0.092
No	406 (93.5)	166 (91.2)	240 (95.2)	
Family history of diabetes				
Yes	36 (8.3)	15 (8.2)	21 (8.3)	0.973
No	398 (91.7)	167 (91.8)	231 (91.7)	
Have other chronic disease				
Yes	176 (40.6)	63 (34.6)	113 (44.8)	0.032
No	258 (59.4)	119 (65.4)	139 (55.2)	
Smoking				
Yes	237 (54.6)	92 (50.5)	145 (57.5)	0.149
No	197 (45.4)	90 (49.5)	107 (42.5)	
Alcohol drinking				
Yes	98 (22.6)	45 (24.7)	53 (21.0)	0.364
No	336 (77.4)	137 (75.3)	199 (79.0)	
Body mass index (kg/m^2)	23.7±3.6	23.2±3.8	24.1±3.5	0.013
Blood pressure (mm Hg)				
Systolic BP	130.3±19.0	130.2±19.6	130.4±18.2	0.920
Diastolic BP	83.7±10.8	83.3±9.9	84.1±11.9	0.448
Waist circumference (cm)	84.9±9.4	83.9±8.4	86.3±10.5	0.011
Hip circumference (cm)	92.0±10.4	91.4±9.9	92.9±11.2	0.131
Waist:hip ratio	0.93±0.1	0.91±0.1	0.94±0.1	0.025

Data were described as n (%) or mean±SD; t-test was used for continuous variables and χ^2 test was used for categorical variables.
BP, blood pressure.

findings of an earlier study.[39] As previously reported and discussed, the prevalence of pre-diabetes is rapidly increasing in rural areas of China, which means there is a need to pay more attention to prevention.[25]

According to this study, the elderly with pre-diabetes in rural areas reported a median physical activity of 524 MET-min/week, and 58.1% of the elderly with pre-diabetes were physically inactive, while 41.9% of them were physically active. This is similar to other studies.[40 41] Taylor *et al*[40] reported that 38% of people with pre-diabetes were physically active. In the Diabetes Prevention Program (DPP) study,[41] the baseline median leisure-time physical activity was 534 MET-min/week. However, it was lower than the Diabetes Prevention Study, which reported that at least 50% of participants were considered physically active,[42] more than a diabetic population, which reported only 32% of people with diabetes were physically active using current physical activity guidelines.[43] On one hand, this may be that the mean age of our study subjects was much higher than these two studies.[42 43] On the other hand, significant chronic conditions, functional limitations and lower fitness levels should also be considered.

Table 2 HRQoL score measured by SF-36 (physical and mental components)

Variables	Physical component score			Mental component score		
	Mean	95% CI	P value	Mean	95% CI	P value
Age group						
60–69 years	43.0	41.4 to 44.6	0.048*	46.0	44.5 to 47.6	0.734*
70–79 years	42.0	39.9 to 44.0		46.6	44.9 to 48.3	
≥80 years	37.2	31.2 to 43.3		47.5	43.3 to 51.8	
Gender						
Male	41.1	39.2 to 43.1	0.193†	44.8	43.0 to 46.6	0.019†
Female	42.8	41.2 to 44.4		47.5	46.1 to 48.9	
Education						
Less than 1 year	40.8	37.7 to 43.8	0.592*	44.4	41.9 to 47.1	0.035*
1–6 years	42.4	40.8 to 43.9		46.1	44.7 to 47.6	
6 years and above	42.6	39.8 to 45.5		49.2	46.9 to 51.6	
Marital status						
Married	41.8	40.3 to 43.4	0.505†	47.3	46.1 to 48.6	0.007†
Non-married	42.8	40.5 to 45.0		43.9	41.5 to 46.3	
History of hyperglycaemia						
Yes	36.6	30.5 to 42.8	0.025†	44.7	40.6 to 48.8	0.445†
No	42.5	41.2 to 43.8		46.5	45.3 to 47.7	
Family history of diabetes						
Yes	42.7	37.7 to 47.8	0.770†	48.8	44.8 to 52.8	0.200†
No	42.1	40.8 to 43.3		46.2	45.0 to 47.3	
Have other chronic disease						
Yes	40.2	38.2 to 42.3	0.012†	45.1	43.3 to 47.0	0.058†
No	43.5	41.9 to 45.0		47.3	45.9 to 48.7	
Smoking						
Yes	42.1	40.5 to 43.7	0.976†	47.1	45.6 to 48.7	0.155†
No	42.1	40.2 to 44.1		45.5	43.9 to 47.2	
Alcohol drinking						
Yes	42.1	40.7 to 43.5	0.999†	46.5	45.3 to 47.9	0.601†
No	42.1	39.2 to 45.0		45.8	43.6 to 48.1	
Body mass index						
Lean	40.3	34.3 to 46.2	0.013*	44.0	39.6 to 48.4	0.182*
Normal	44.1	42.6 to 45.5		47.4	45.9 to 48.8	
Overweight	40.1	37.5 to 42.7		44.9	42.5 to 47.5	
Obese	39.3	34.9 to 43.6		47.0	44.0 to 49.6	
Blood pressure						
Abnormal	41.4	39.7 to 43.2	0.280†	45.9	44.3 to 47.5	0.689†
Normal	42.8	41.0 to 44.7		46.4	44.8 to 47.9	
Waist:hip ratio						
Abnormal	40.6	39.0 to 42.2	0.012†	45.5	43.9 to 47.0	0.093†
Normal	43.8	41.9 to 45.7		47.4	45.8 to 49.0	

*ANOVA test for trend.
†P values were determined by t-test.
ANOVA, analysis of variance; HRQoL, health-related quality of life; SF-36, Medical Outcomes Study 36-Item Short Form Health Survey.

Table 3 Total physical activity score of pre-diabetes measured by IPAQ-long version

Variables	Total physical activity (MET-min/week)	Z value	P value
Age group			
60–69 years	560.0 (0–797.5)	2.81	0.245*
70–79 years	465.0 (0–745.0)		
≥80 years	386.0 (60.0–693.0)		
Gender			
Male	567.5 (105.0–858.5)	2.25	0.025†
Female	462.0 (0–726.5)		
Education			
Less than 1 year	465.0 (0–697.0)	1.45	0.485*
1–6 years	560.0 (0–780.0)		
6 years and above	500.0 (0–840.0)		
Marital status			
Married	520.0 (0–755.0)	0.62	0.539†
Non-married	542.0 (0–845.0)		
History of hyperglycaemia			
Yes	500.0 (0–772.0)	2.21	0.027†
No	682.0 (467.5–875.5)		
Family history of diabetes			
Yes	560.0 (252.0–769.5)	0.54	0.592†
No	512.0 (0–780.0)		
Have other chronic disease			
Yes	420.0 (0–693.0)	2.33	0.020†
No	590.0 (0–810.5)		
Smoking			
Yes	462.0 (0–717.5)	2.15	0.032†
No	575.0 (60.0–869.0)		
Alcohol drinking			
Yes	579.0 (90.0–792.0)	1.36	0.174†
No	495.0 (0–760.5)		
Body mass index (BMI)			
Lean	555.0 (0–750.0)	6.88	0.076*
Normal	560.0 (0–791.0)		
Overweight	415.0 (0–715.5)		
Obese	345.0 (0–598.0)		
Blood pressure			
Abnormal	560.0 (0–785.5)	1.33	0.184†
Normal	462.0 (0–735.0)		
Waist:hip ratio			
Abnormal	487.5 (0–792.5)	0.37	0.715†
Normal	546.0 (0–755.0)		

Data were described as median (P_{25}–P_{75}).
*P value was determined by Kruskal-Wallis test.
†P value was determined by Mann-Whitney U test.
IPAQ, International Physical Activity Questionnaire; MET, metabolic equivalent.

Table 4 Bivariate Spearman's correlations between health-related quality of life, sociodemographics and health characteristics

	1	2	3	4	5	6	7	8	9
1. Age	1.000								
2. Gender	−0.037	1.000							
3. Smoking	−0.056	−0.247**	1.000						
4. Chronic disease	0.111*	0.714**	0.171**	1.000					
5. Body mass index	0.084	0.097*	0.069	0.037	1.000				
6. Waist:hip ratio	0.096*	0.014	0.016	0.020	0.006	1.000			
7. Physical activity	0.034	0.112*	−0.093*	0.134**	0.020	−0.010	1.000		
8. Physical component summary score	0.043	0.048	0.023	−0.133**	−0.076	0.020	0.209**	1.000	
9. Mental component summary score	−0.007	0.196**	0.048	0.061	−0.063	−0.002	0.089	0.182**	1.000

Significant correlation at *P<0.05 and **P<0.01 (two-tailed).
Body mass index in kg/m^2. Physical activity in total metabolic equivalent-min/week.

In addition, the US public health guidelines for physical activity state that all adults should achieve a minimum of moderate-intensity physical activity for 30 min on at least 5 days each week or a minimum of 20 min of vigorous-intensity physical activity on at least 3 days each week to promote health.[36 44] Participants of the physically active group in this study attained 600 MET-min/week, which was equal to 150 min/week of moderate activity, indicating that they achieved the public health guidelines for physical activity.

Although the effect of physical activity on HRQoL has been widely discussed among some populations in the previous literature,[17 20 45–50] there are few studies that explore the association between physical activity and HRQoL in individuals with pre-diabetes, and especially there is a lack of research among the elderly with pre-diabetes. To our knowledge, this is the first study to investigate the influence of physical activity on HRQoL in the elderly with pre-diabetes. In support of our hypotheses, we found that physical activity was associated with HRQoL among elderly individuals with pre-diabetes, after adjusting for several HRQoL correlates. More specifically, physically active participants reported higher PCS scores than physically inactive participants. These results are generally consistent with previous research that targeted different populations,[40 51] indicating that there are positive associations between physical activity and HRQoL. Taylor *et al*[40] found that people with pre-diabetes who were physically active reported 2.7 points higher on physical health and 3.0 points higher on the mental health component of HRQoL than those physically inactive after adjusting for many covariates. Häkkinen *et al*[51] found that individuals at 'high risk' of developing type 2 diabetes who engaged in physical activity two or more times per week had a better perception of general health and physical functioning compared with those not engaging in physical activity, although Ibrahim *et al*[52] found that physical activity was not a strong predictor of HRQoL among individuals with pre-diabetes. This may be that the authors stratified by BMI when analysing the association between physical activity and HRQoL, and the small sample size in the BMI subgroup may not have adequate power to produce significant associations between physical activity and HRQoL. If a change of 5–10 points in the SF-36 scores has been suggested as being clinically significant for clinical populations with a variety of illnesses,[53 54] the

Table 5 Association between physical activity and health-related quality of life (physical and mental components)

	Physically active		Physically inactive		Difference		
Variables	Mean	SE	Mean	SE	M_{diff}(95% CI)	ES(d)	P value
Crude analysis (Wilks' λ=0.956, *F*(2,431)=10.03, P<0.001)							
PCS	45.3	0.93	39.8	0.84	5.6 (3.2 to 8.1)	0.55	<0.001
MCS	47.3	0.78	45.7	0.80	1.6 (–0.7 to 3.8)	0.21	0.173
Adjusted analysis (Wilks' λ=0.962, *F*(2,423)=8.44, P<0.001)*							
PCS	45.1	0.97	39.9	0.83	5.2 (2.5 to 7.6)	0.47	<0.001
MCS	47.4	0.87	45.6	0.74	1.7 (–0.5 to 4.1)	0.26	0.127

*Adjusted for age, gender, marital status, education, smoking, chronic disease, body mass index and waist:hip ratio.
ES(d), mean difference/pooled SD; M_{diff}, mean difference; MCS, mental component summary score; PCS, physical component summary score.

differences in this study are important and meaningful, especially on the PCS of HRQoL, since they are observed in a population with pre-diabetes.

Another interesting finding of our study was that only the physical component score of HRQoL showed differences between the physically active and inactive groups. This result is consistent with some studies.[55 56] Nakamura *et al*[55] found that the level and intensity of physical activity were not associated with the mental health domain for women. Morimoto *et al*[45] found that women who performed physical activity had higher HRQoL in almost all domains except for mental health and social function, and other two studies have shown that the physical and mental aspects of HRQoL were associated with physical activity.[57 58] However, the relationship between physical activity and the mental component of HRQoL is not entirely clear. First, the association between physical activity and the mental health domain may be mediated through differences in maximal oxygen uptake and body fat percentage, or due to emotional health.[59 60] Second, these differences may be related to different categorisations of physical activity, different instruments to assess HRQoL and the evaluation of different ages and genders.

The third interesting finding in this study was that individuals with pre-diabetes showed lower physical component scores compared with the mental health component scores, which was consistent with other studies.[40 52] This may be because some of the elderly with pre-diabetes have difficulties in physical activities due to their sick body. Study has shown that chronic diseases have a stronger effect on reducing the physical function than psychological function.[61] In this elderly population with pre-diabetes, more than 40.0% had at least one chronic disease and majority were overweight or obese, and studies have reported that many individuals with pre-diabetes were uncertain about their disease, and they considered pre-diabetes to be not serious and easily accepted.[62 63]

Results from this study provided evidence for differences in HRQoL among the elderly with pre-diabetes compared with the general population. Individuals with pre-diabetes reported a mean PCS score of 42.1±10.2 and a mean MCS score of 46.4±8.9, suggesting that their health status was slightly lower compared with population norms ($P<0.05$).[34] Many studies also identified that individuals with IGT were more likely to report lower HRQoL scores compared with those with normal glucose tolerance (NGT).[12 63] These reports suggest that individuals with pre-diabetes may receive HRQoL benefits from related interventions. However, individuals with pre-diabetes who are physically active have better PCS scores than those who were physically inactive, suggesting that physical activity may be adapted to HRQoL intervention for pre-diabetes. If the positive health benefits of physical activity are well perceived, it is important to plan public health interventions designed to promote physical activity and decrease sedentary lifestyle. Moreover, based on physical activity, lifestyle intervention can reduce the incidence of diabetes among individuals with pre-diabetes.[60] But for the elderly, the intensity of activity should take into account muscle fitness and cardiopulmonary endurance; thus, activities focused on maintaining or increasing flexibility are recommended.[64]

Our study has several limitations. First, our study used a cross-sectional study design, which did not allow a causal relationship to be established. Thus, future studies need to conduct both longitudinal and randomised controlled trial designs to garner a deeper understanding of the relationship between physical activity and HRQoL. Second, self-administered questionnaires were used to assess physical activity and HRQoL; therefore, an inaccurate estimation of the physical activity and HRQoL and recall bias were unavoidable. However, this limitation was minimised because both instruments used in this study are valid and reliable.[30 35] Third, we did not consider the specific variation regarding level and intensity as well as domain-specific physical activity on HRQoL, even though different intensities and domains of physical activity have different influences on HRQoL.[56 65] Considering the large population of elderly with pre-diabetes and suitably using the IPAQ-long version and the SF-36 assessment tool, the results of this study are generalisable.

CONCLUSIONS

In summary, elderly individuals with pre-diabetes in the rural Hunan Province of China reported a relatively lower HRQoL score. Only 41.9% of them reported a total physical activity score higher than 600 MET-min/week. Rural elderly with pre-diabetes who were physically active reported a higher HRQoL score only on the physical component compared with those who were physically inactive. Further studies need to be conducted to garner a deeper understanding of the relationship between physical activity and HRQoL.

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