



# The effects of clinical illness severity and physical activity on health-related quality of life in schizophrenia

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## Abstract

**Background** Quality of life is an important clinical outcome in individuals with schizophrenia. Illness severity and physical activity (PA) were independently reported to influence health-related quality of life (HRQoL) in people with schizophrenia. This study attempts to examine the intensity and types of PA and their impact on HRQoL, as well as the relative contributions of illness severity, PA, and sedentary behavior (SB) to HRQoL in people with schizophrenia.

**Methods** Demographic information was collected from 297 community-dwelling individuals with schizophrenia. Severity of illness was assessed on the Clinical Global Impression—Severity (CGI-S); PA and SB were assessed on the Global Physical Activity Questionnaire (GPAQ); HRQoL was assessed on the RAND-36. Regression analyses were conducted to examine the impact of different types and intensities of PA on HRQoL, and the relative impact of CGI-S, GPAQ-PA, and GPAQ-SB on HRQoL.

**Results** Most participants had low PA level, and travel is the main type of PA adopted. Leisure time, travel-related, work-related, moderate-, and vigorous-intensity PA were all not associated with HRQoL. Lower severity of illness was significantly associated with better physical (PHC), mental (MHC) and global (GHC) health composites of the RAND-36 (GHC:  $t = -5.628$ ,  $p < 0.001$ , PHC:  $t = -4.026$ ,  $p < 0.001$ , MHC:  $t = -5.534$ ,  $p < 0.001$ ). Both PA and SB were not significantly associated with PHC, MHC, and GHC.

**Conclusion** Severity of illness has a significant impact on HRQoL in people with schizophrenia. However, we found no evidence to support the association between physical activity and sedentary behavior with HRQoL.

**Keywords** Schizophrenia · HRQoL · Physical activity · Sedentary behavior · Illness severity

## Introduction

Schizophrenia is a chronic and debilitating mental disorder that was associated with significant functional impairments [1]. The outcome measures in schizophrenia might extend from the objective assessment of psychopathology and functioning to more subjective elements aiming to understand individuals' perception and experience of life, e.g., quality of life (QoL). Health-related quality of life (HRQoL) assesses how health has affected an individual's subjective perception of his or her health status and mental and physical well-being [2]. A study by Boyer et al. [3] suggested that higher HRQoL as measured on the Medical Outcome Study 36-Item Short Form Health Survey (SF-36), a generic HRQoL measure, was predictive of a lower rate of relapse in schizophrenia two years later. QoL was also incorporated into prediction models for remission in schizophrenia, in addition to symptomatic status and

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functioning [4]. People with schizophrenia were found to have a lower QoL when compared to the general population [5, 6]. The scores on all SF-36 domains, except body pain, were lower in people with schizophrenia as compared to their age- and gender-matched healthy counterparts [7]. Better QoL was associated with better functioning, social support, and cognition, as well as lower psychopathology and depressive symptoms [8–12].

Suboptimal lifestyle such as a lack of physical exercise, smoking, and alcohol use were associated with shorter life expectancy in people with psychosis [13, 14]. Individuals with schizophrenia were found to engage in more sedentary behaviors (SB) and less physical activities (PA) than the healthy controls [15, 16]. SB was associated with higher likelihood of developing metabolic syndrome and lower QoL in people with schizophrenia [16, 17]. PA, on the other hand, was associated with better QoL in general population [18, 19], while physical exercise was associated with better QoL in people with schizophrenia [20, 21]. Systematic reviews on physical exercises also concluded that exercises were associated with reduced psychotic symptoms, lower metabolic risks, improved functioning, and better QoL in people with schizophrenia [22–26].

PA, physical fitness (PF), and physical exercise are different constructs [27, 28]. PA involves body movements that results in energy expenditure, PF is related to skills and health components like strength, endurance, and flexibility, while exercise is planned and structured PA conducted repetitively with purpose to improve PF, and exercise intervention has structured activities under guided environment [21, 27, 28]. The impact of these different constructs on different domains of QoL may not be the same and findings were not consistent. Increment in physical activity (PA) in inpatients with schizophrenia was associated with improvement in QoL [29]. Engaging in active leisure activities was associated with lower negative emotion and better physical HRQoL in people with schizophrenia [7, 30]. However, Bonsaksen and Lerdal found that HRQoL was not associated with PA in inpatients with severe mental illness [31]. HRQoL was associated with PF, but much lesser extent with reported PA and had no association with accelerometer in people with cystic fibrosis [32]. Certain levels of frequency, duration, and intensity of PA were suggested to develop and maintain PF [33]; while higher exercise dose was associated with improvements in QoL after 6 months in postmenopausal women [34]. Nonetheless, the association between PA dose and HRQoL may not be linear and daily moderate and vigorous PA as well as very short or extended periods of PA was associated with poorer HRQoL in general population [35]. In addition, PF was associated with HRQoL in healthy subjects but not in people with schizophrenia [36]. The majority evidence to date pointed to association between physical exercise and QoL, but investigation on the impact

of different intensities and types of PA on HRQoL in people with schizophrenia was relatively scarce.

Symptoms of schizophrenia were associated with poorer QoL in individuals with schizophrenia [37–40]. Studies showed that reduction in positive symptoms, negative symptoms, emotional distress, and cognitive issues were associated with better QoL [41–44]. Psychopathology was associated with physical HRQoL but not mental HRQoL in a study by Vancampfort et al. [44]. Also, aerobic fitness was not significantly associated with HRQoL after controlling for impact of psychopathology [44]. The impact of severity of psychopathology on different domains of HRQoL in schizophrenia, as well as the unique association between PA and HRQoL after controlling for severity of illness remains an unexplored area.

This study aims to investigate PA and SB in people with schizophrenia, as well as the association between different types and intensities of PA with Physical (PHC), Mental (MHC), and Global (GHC) Health domains of HRQoL in people with schizophrenia. Furthermore, we aim to explore the associations and relative contribution of severity of illness, PA, and SB on PHC, MHC, and GHC. We hypothesize that lower severity of illness, higher PA, and lower SB are associated with better HRQoL.

## Method

### Participants

340 individuals with schizophrenia were approached in outpatient clinics in a tertiary mental health hospital in Singapore from 2012 to 2015. 42 of them were either not interested to participate in the study or did not meet screening criteria of the study, 1 of them withdrew from the study, and 297 completed the study. 1 outlier was deleted from data analyses. Eligible patients were referred by clinicians who had assessed them to have a stable mental state and fit to give informed consent. Trained research staff briefed the patients about the study using a standard information sheet and obtained signed informed consent from all enrolled study participants in accordance with guidelines laid down by the ethics board. This study was approved by the Domain Specific Review Board of the National Health Group, Singapore (DSRB Ref: 2012/00933).

Demographic information including age, sex, ethnicity, education, marital status, employment status, household income, residence type, smoking status, alcohol consumption, antipsychotic dose, duration of illness, and duration of psychiatric treatment was collected. Height and weight were measured and body mass index (BMI) was calculated for each participant. Antipsychotic dose was calculated as total daily chlorpromazine (CPZ) equivalents.

## Instruments

The participants were assessed on the Clinical Global Impression—Severity scale (CGI-S), a clinically intuitive scale widely used to assess illness severity in people with schizophrenia [45–47]. The CGI-S categorizes a person's overall severity of mental illness with a seven-point system, from “1: normal, not at all ill” to “7: among the most extremely ill patients.”

PA was evaluated using the Global Physical Activity Questionnaire (GPAQ) [48], a self-report questionnaire which probes about intensity and time spent on PA at work and recreation, travel to and from places, and time spent on SB. GPAQ was found to be equivalent to International Physical Activity Questionnaire (IPAQ) [49–51], which was validated for use in individuals with schizophrenia with reliability and validity comparable to those found in general population [52, 53]. Specifically, when IPAQ was used in schizophrenia, test–retest reliability of PA minutes was reported to be moderate ( $r_s = 0.47–0.68$ ); Spearman's correlation that indicate criterion validity between IPAQ and accelerometer was small ( $r_s = 0.30–0.37$ ) [52, 53]; test–retest reliability of GPAQ in general population was also shown to be moderate ( $r_s = 0.55–0.69$ ), while association that indicates criterion validity with accelerometer was fair ( $r_s = 0.20–0.46$ ) [54, 55]. GPAQ and IPAQ had good concurrent validity ( $r_s = 0.45–0.94$ ) [49, 51].

MET minutes (Metabolic equivalents of task) were used to capture the total time spent on different intensities of PA in a week. Specifically, one MET denotes the energy cost of being in a sedentary state (e.g., sitting quietly). Time spent on moderate-intensity activities and time travel to a place continuously for at least 10 min were multiplied by a MET value of 4, while time spent on vigorous-intensity activities were multiplied by a MET value of 8 to form GPAQ-Physical. GPAQ-Physical estimates energy consumption on PA in a week, while GPAQ-Sedentary assesses the total amount of time spent on SB in a typical day. Energy consumption on leisure time, work-related, travel-related, moderate-, and vigorous-intensity PA was also computed. Participants' levels of total PA were categorized into three categories according to the GPAQ analysis guide [56]. A binary variable on whether or not World Health Organization (WHO) recommendation on PA for health is met was computed using the criteria adopted in two local studies [55, 57]. GPAQ-Sedentary was dichotomized by being sedentary for 8 h or more to compute GPAQ-Sedentary-Binary.

HRQoL was evaluated using the RAND-36 Health Status Inventory [58] distributed by the Psychological Corporation. Although less commonly used, the RAND-36 has the same items with differences in scoring as compared to SF-36 [2, 59], which was widely used in HRQoL assessment in schizophrenia [60]. The RAND-36 scoring was

based on item response theory and factor-based composite scores [59]. It was reported to have decent internal consistency, e.g., alpha reliability coefficients of 0.60–0.87 were reported for an English version and 0.56–0.89 for an Arabic version in company employees [61], and reliabilities of 0.80 above was reported for most subscales in people with multiple sclerosis, rheumatism, asthma, chronic bronchitis, or lung emphysema [62]. Cronbach's Alpha reported in SF-36 was generally similar to coefficients reported for RAND-36, e.g., internal consistency of 0.64–0.92 was reported in Dutch inhabitants with musculoskeletal diseases [63], and 0.66–0.93 was showed in people with cancer, migraine, and general population [64]. Construct validity of SF-36 was supported in normal working adults [65] and also indicated by decent CFA fit indices in people with schizophrenia [66]. Orthogonal factor rotation was used for SF-36, while oblique rotation which factors were allowed to correlate was used in RAND-36. Studies showed that the physical and mental health factors were moderately correlated [67, 68], therefore oblique rotation would be a more realistic representation [58].

RAND-36 contains 36 items to measure eight domains of health status represented by two factors—Physical (PHC) and Mental (MHC) Health Composites. PHC comprised of physical functioning, role limitations due to physical health, pain, and general health, while MHC comprised of role limitation due to emotional problems, energy/fatigue, emotional well-being, and social functioning. PHC, MHC, and a global score of HRQoL (GHC) were computed from the HRQoL scale following the RAND-36 manual. The responses in each item were first recoded to IRT weight assigned to each response, and all IRT weights of the items that belong to a domain were summed to form a raw score. In our study, because of the distinct differences in ethnicity composition and education system, the raw scores were not converted to T scores stratified by age, ethnicity, and education according to the US norm. Raw scores were used instead, to be multiplied with the assigned weights for each domain, and the relevant weighted domain scores were then summed to form PHC, MHC, and GHC scores.

## Data analysis

Descriptive statistics of demographic information and clinical characteristics of the sample, RAND-36, PA, and SB were examined. To examine the association of different types and intensities of PA with PHC, MHC, and GHC, total energy consumption in leisure time, work-related, travel-related, moderate-, and vigorous-intensity PA was entered in linear regression as independent variables with PHC, MHC, and GHC as dependent variables. To determine possible covariates for the models, each of the demographic variables was first entered as independent variables

in linear regression analyses with PHC, MHC, and GHC as dependent variables, respectively. The demographic variables that were significantly associated with PHC, MHC, or GHC at  $p < 0.05$  were subsequently entered in multivariate regression analyses as covariates, with GPAQ-Physical, GPAQ-Sedentary, and CGI-S as independent variables and PHC, MHC, and GHC as dependent variables, respectively. Assumptions of multivariate regression models were also examined. Effect sizes of GPAQ-Physical, GPAQ-Sedentary, and CGI-S on GHC, PHC, and MHC, respectively, were estimated using Cohen's  $f^2$ , where 0.02 indicates small effect size, 0.15 indicates medium effect size, and 0.35 indicates large effect size [69, 70].

Analyses were conducted on IBM SPSS Statistics Version 23.

## Results

Description of the study sample is shown in Table 1. Most of the participants were well maintained in terms of severity of mental illness. Using Asian BMI cut-off, 90 (30.4%) of the participants were overweight, and 119 (40.2%) were obese. 136 (45.9%) reported being sedentary for more than 8 h a day and 144 (48.6%) met WHO recommendation for PA. Among participants who met WHO recommendation for PA, 55 (38.2%) were obese, 53 (36.8%) were overweight. 34 (11.5%), 110 (37.2%) and 152 (51.4%) participants were categorized as having high, moderate, and low level of total PA, respectively. Travel accounted for 53.63% of PA, while 25.81% of PA was contributed by work and 20.56% by leisure activity. 96.58% of PA were of moderate-intensity level.

Leisure time, work-related, travel-related, moderate-, and vigorous-intensity PA, GPAQ-Sedentary, and GPAQ-Sedentary-Binary were all not associated with PHC, MHC, and GHC. Sex, ethnicity, alcohol consumption, residence type, current employment status, duration of illness, duration of treatment, and household income were all not associated with PHC, MHC, and GHC. Age, marital status, and antipsychotic dose were significantly associated with MHC; BMI was significantly associated with PHC; and education level and smoking status were significantly associated with both PHC and GHC. The results of unadjusted linear regressions are shown in Table 3 in Appendix.

Assumptions of multivariate regression models were all met. There was no evidence of multicollinearity. First, the highest correlation coefficients observed was correlation between current and past smoking,  $r = 0.664$ ,  $p < 0.001$  in both GHC and PHC models. Second, tolerance and VIF values were in acceptable ranges (tolerance  $> 0.10$  and  $VIF < 4$ ). In GHC model, tolerance values = 0.527–0.983, VIF values = 1.017–1.899, the lowest tolerance and highest VIF values were observed between current and past smoking

(tolerance = 0.527–0.556,  $VIF = 1.798$ –1.899). In PHC model, tolerance = 0.526–0.983,  $VIF = 1.018$ –1.902, with the lowest tolerance and highest VIF obtained on current and past smoking (tolerance = 0.526–0.546,  $VIF = 1.833$ –1.902). In MHC model, tolerance = 0.907–0.987 and  $VIF = 1.013$ –1.103. Residuals appeared to be independent, and Durbin–Watson values were all close to 2 (2.002 in GHC, 2.030 in PHC, 1.958 in MHC). Scatterplots of standardized residuals versus standardized predicted value did not suggest heteroscedasticity. Furthermore, Breusch–Pagan tests yielded non-significant results for all three models, suggesting homoscedasticity. P–P plots suggested the values of residuals were normally distributed for all models and that the assumption of normality of residuals is met. Cook's distance for all three models was less than 0.15, indicating the results were not biased by individual cases.

CGI-S was negatively and significantly associated with GHC ( $t = -5.628$ ,  $p < 0.001$ ), PHC ( $t = -4.026$ ,  $p < 0.001$ ), and MHC ( $t = -5.534$ ,  $p < 0.001$ ). Age was significantly associated with MHC ( $t = 2.552$ ,  $p = .011$ ). GPAQ-Physical and GPAQ-Sedentary were not significantly associated with GHC, PHC, and MHC. Effect sizes of GPAQ-Physical, GPAQ-Sedentary, and CGI-S on GHC, PHC, and MHC, respectively, were small, Cohen's  $f^2 = 0.10$  for GHC, Cohen's  $f^2 = 0.049$  for PHC, and Cohen's  $f^2 = 0.097$  for MHC. The results are shown in Table 2.

## Discussion

The present study sought to understand PA and SB in individuals with schizophrenia, impact of different types and intensities of PA on HRQoL, and to examine the relative contributions of illness severity, PA, and SB to HRQoL in individuals with schizophrenia. Our results showed that most participants had low level of PA, and travel constituted the major proportion of their PA. Types and intensities of PA were not associated with any aspect of HRQoL. More severe mental illness was associated with lower physical, mental, and global HRQoL, and accounted for more variance than PA and SB in HRQoL. It was suggested that effect sizes ranging from 0.09 to 0.28 in RAND-36 would be considered clinically important [58]. In our study, effect sizes of illness severity, PA, and SB on GHC and MHC were clinically significant (Cohen's  $f^2 = 0.097$ –0.10), while effect size did not attain clinical significance for PHC (Cohen's  $f^2 = 0.049$ ). This is consistent with the evidence that people with depression showed worse mental well-being as compared to people with chronic medical illnesses [58]. In people with schizophrenia, it is possible that illness severity, PA, and SB were more relevant to mental well-being. Nevertheless, appropriate caution should be exercised in interpreting clinical significance for clinical decision, activities that only require

**Table 1** Demographic and characteristics of participants

Variable	Mean or <i>n</i> (% or SD)
Sex (male)	166 (56.1%)
Age	39.83 (SD = 9.20)
Duration of illness (year)	15.72 (SD = 8.65)
Duration of psychiatric treatment (year)	15.10 (SD = 8.53)
BMI	26.40 (SD = 5.17)
Ethnicity	
Chinese	257 (86.8%)
Malay	14 (4.7%)
Indian	25 (8.4%)
Smoking status	
Smoker	60 (20.27%)
Ex-smoker	110 (37.16%)
Non-smoker	126 (42.57%)
Alcohol consumption	
Current	70 (23.6%)
Past	79 (26.7%)
Non-user	147 (49.7%)
Education level	
No education	7 (2.4%)
Primary	52 (17.6%)
Secondary	77 (26.0%)
Vocational	38 (12.8%)
Pre-U/Diploma	88 (29.7%)
Degree and above	34 (11.5%)
Marital status	
Never married	233 (78.7%)
Married	36 (12.2%)
Separated	3 (1.0%)
Divorced	20 (6.8%)
Widowed	4 (1.4%)
Employment status (employed)	144 (48.6%)
Antipsychotic dose* (mg)	484.05 (SD = 406.56)
CGI-S	2.46 (SD = 1.17)
Normal	79 (26.7%)
Borderline mentally ill	78 (26.4%)
Mildly ill	73 (24.7%)
Moderately ill	56 (18.9%)
Markedly ill	10 (3.4%)
GPAQ-Physical activities (MET minutes/week)	1522.66 (SD = 2404.44)
GPAQ Vigorous activities-Work (MET minutes/week)	36.08 (SD = 421.65)
GPAQ Vigorous activities-Leisure (MET minutes/week)	47.30 (SD = 281.13)
GPAQ Moderate activities-Work (MET minutes/week)	762.57 (SD = 2100.13)
GPAQ Moderate activities-Leisure (MET minutes/week)	186.51 (SD = 423.81)
GPAQ Travel more than 10 min (MET minutes/week)	490.20 (SD = 742.59)
GPAQ-Sedentary behavior (minutes/day)	453.97 (SD = 252.61)
RAND-36 GHC	277.72 (SD = 61.74)
RAND-36 PHC	303.42 (SD = 61.81)
RAND-36 MHC	213.22 (SD = 60.94)

\*Antipsychotic doses were converted into total daily chlorpromazine equivalents

**Table 2** Multiple regression with CGI, GPAQ-Physical activity, and GPAQ-Sedentary behavior on RAND-36 composite scores

Independent variables	GHC				PHC				MHC			
	B	SE	t	p	B	SE	t	p	B	SE	t	p
CGI-S	-16.517	2.935	-5.628	<0.001	-11.999	2.980	-4.026	<0.001	-16.372	2.958	-5.534	<0.001
GPAQ-Physical	-0.000041	0.001	-0.029	0.977	-0.001	0.001	-0.612	0.541	0.001	0.001	0.406	0.685
GPAQ-Sedentary	-0.006	0.014	-0.477	0.634	-0.011	0.014	-0.780	0.436	-0.003	0.013	-0.237	0.813
Age (year)									0.980	0.384	2.552	0.011
Antipsychotic dose*									-0.013	0.008	-1.580	0.115
Education level	2.460	2.562	0.960	0.338	4.057	2.611	1.554	0.121				
BMI					-1.461	0.680	-2.148	0.033				
Smoking status												
Current smoker	-17.770	11.595	-1.533	0.126	-16.325	11.781	-1.386	0.167				
Ex-smoker	-7.141	9.438	-0.757	0.450	-3.760	9.674	-0.389	0.698				
Marital Status												
Married									-9.667	10.551	-0.916	0.360
Separated									-72.139	33.277	-2.168	0.031
Divorced									10.793	13.603	0.793	0.428
Widowed									42.969	29.349	1.464	0.144

Model summary: GHC ( $R^2=0.132$ ,  $F(6,286)=7.247$ ,  $p<0.001$ ); PHC ( $R^2=0.111$ ,  $F(7,285)=5.063$ ,  $p<0.001$ ); MHC ( $R^2=0.159$ ,  $F(9,283)=5.933$ ,  $p<0.001$ )

CGI-S Clinical Global Impression-Severity, GPAQ Global physical activity questionnaire, BMI body mass index

\*Antipsychotic doses were converted into total daily chlorpromazine equivalents

minimal resources may still be worthwhile doing even if the effects do not attain clinical significance [58].

The finding on the negative association between illness severity and HRQoL is consistent with previous studies. More severe clinical symptoms were associated with poorer QoL in individuals with first-episode schizophrenia [40, 71] and schizophrenia [37, 38]. CGI-S was negatively associated with all SF-36 domains [72], and a pooled analysis from eight longitudinal studies showed that changes in schizophrenia symptoms were inversely associated with changes in QoL [42].

BMI had marginally significant negative association with PHC. Obesity was associated with physical factor of SF-36 in general population [73, 74] and in people with schizophrenia [75]. Similar to Folsom et al. [5], age had significant positive association with MHC in our study. However, different findings exist in literature [43, 76]. Ritsner et al. [43] showed non-significant association between HRQoL with education and duration of treatment, while Tan et al. [76] indicated that years of education, gender, marital status, and social-economic class were not associated with HRQoL. The differences in findings may be due to the use of different HRQoL measures and characteristics of different samples. Employment status was not associated with HRQoL in our study. This is consistent with Eklund's [77] suggestions that employment status is minor in QoL in people with severe mental illness and meaningful daily activities were more important.

The study found no significant associations between types and intensities of PA, GPAQ-Sedentary, and GPAQ-Physical with HRQoL. The lack of association between PA and QoL is consistent with Bonsaksen and Lerdal [31] but the study only had 18 inpatients with severe mental illness. The evidence on beneficial effects of PA on QoL [22–24] mostly investigated impacts of exercise interventions like aerobic, anaerobic, yoga, and Tai chi on QoL. A study showed that aerobic fitness, but not PA, was associated with SF-36 [44]. It may be possible that PF that is relatively stable, instead of PA that is more variable [27], has stronger impact on HRQoL. A systematic review on neurobiological impact of physical exercise in people with schizophrenia also found that possible reason of different findings on effects of exercise on hippocampal volume was the difference in average exercise frequency, and people with lower exercise frequency did not exhibit hippocampal volume increment [78]. These suggested that the intensity and frequency of exercise and PF would be more important than the actual doing of PA itself.

Similar to the findings in two local studies in the general population [55, 57], larger proportions of PA in our sample were moderate-intensity activity and travel-related activity; vigorous PA constituted a very small proportion. Similar results were also found in two meta-analyses on people with schizophrenia indicating that they engaged in more light-moderate PA but significantly less in moderate-vigorous activities [15, 79]. Unfortunately, light PA was not captured

in GPAQ. Also, studies showed that engagement in broad varieties of activities and activities with higher intensity may be more beneficial to health and HRQoL [80–82].

Vancampfort et al. [7] showed that lack of PA during leisure time was associated with impaired physical HRQoL. Leisure-time PA only accounted for 21% of total PA in our sample, PA conducted to fulfill responsibilities and to travel may not have significantly contributed to HRQoL. Furthermore, negative symptoms, particularly avolition and anhedonia, may be associated with both PA [83] and HRQoL [6, 8, 37, 40, 84], and may attenuate the association between both variables. Similarly, self-determination was suggested to influence the initiation and persistence of health-promoting PA in people with schizophrenia [85]. Satisfaction with activities and the value of activities were associated with subjective QoL [77, 86, 87]; it would be possible that satisfaction level experienced and the value individuals assigned to an activity, rather than doing an activity per se, have significant association with HRQoL. Other variables such as self-efficacy and attitudes towards PA would also influence the associations between PA and HRQoL. Self-efficacy was suggested to mediate the relationship between PA and QoL in people with multiple sclerosis [88] and elderly [89, 90] in a social cognitive model. Besides, it is possible that the strength of associations found were diluted by measurement error from the use of composite scores, i.e., GHC, PHC, and MHC that were latent variables. Psychotic symptoms, medication side effects, and non-supportive social environment were reported to be the barriers to leisure-time PA in individuals with severe mental illness [83, 91]; contradictorily, these are the domains that were shown to be improved with participation in PA [22–24]. The underlying factors leading to the more active lifestyle and better HRQoL would be worthy of future research.

Between-subject variability in PA scores may also be affected by other factors. MET values adopted may be more appropriate for people with normal weight but an overestimation for the obese people as energy expenditure per kilogram body mass is lower in the obese [92]. The energy cost for activities may also vary with gender, age, and fitness levels [93]. In addition, environment in which people perform PA may have influences on total energy expenditure [93]. One's interpretation of moderate- and vigorous-intensity may be different from another, and it has been shown that participants often understand PA in terms of psychological efforts rather than physical efforts [94]. Also, engaging in a sport competitively or leisurely may render an activity to be categorized differently. Within-subject variability is possible especially for people who do not have a routine—information collected from a measure of SB and PA in a typical day or a typical week may not well reflect the variability of activities in people who perform activities sporadically.

The possible influence of limitation of the PA measure on the results should be noted. PA is a complex and multi-faceted construct that involves measurements of PA in occupation, household, leisure, and transport domains described in type, intensity, frequency, and duration [28]. These require participants to recall their activities in a specific period in details, and demand cognitive capability. People with schizophrenia suffer moderate to severe cognitive impairment [95] that may affect their ability to recall details of their activities, which may compromise the accuracy of GPAQ. In addition, the responses to GPAQ may also be affected by social desirability bias, i.e., the reported PA may not be the true representation of PA and SB [27, 51]. Studies have found that participants overestimated their PA [55, 96, 97] and under-reported time spent being sedentary [55, 98].

One of the limitations of our study is only questionnaire measure was used to measure PA. The cross-sectional nature of our study also did not allow the examination of test–retest reliability of GPAQ or the consistency of PA over time. In future research, an objective measure of PA should be adopted along with questionnaire. SB should also be clearly defined and more directly inquired [99]. Technology like mobile apps could be used to facilitate timely record of daily activity to better capture accurate activity information. In computation of composite scores, a more sophisticated weighting system could be employed to differentiate PA conducted leisurely and professionally, as skill levels would affect energy consumption. As most published studies to date focus on moderate- and vigorous-intensity PA, more evidence is needed on the efficacy of light PA on health outcome and QoL in people with schizophrenia. Despite doubts on validity of subjective HRQoL measures in people with schizophrenia [60, 100], patients' subjective perception of their well-being should still be incorporated into their treatment plan [101]. In fact, it was shown that individuals with schizophrenia were able to reliably and validly report their subjective QoL [102, 103]. Cronbach's alpha coefficients of RAND-36 subscales in our study are comparable to those reported in literature; the significant association between illness severity and HRQoL shown in our study also rendered support to the validity of RAND-36 in people with schizophrenia.

To conclude, our study showed that severity of illness is important in HRQoL, therefore management of symptoms is important in subjective well-being in people with schizophrenia. Also, PA might not directly contribute to generic QoL. Determinants that have greater impact on HRQoL and variables that may moderate the associations between PA and HRQoL should be identified and examined. Exploring meaningful activities and programs targeted at internalizing values and cultivating intrinsic motivation would be an important goal for this population.

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## Compliance with ethical standards

**Conflict of interest** JL has received honoraria from Roche and Janssen-Cilag in the past 5 years. All other authors have no conflicts of interests to declare.

## Appendix

See Table 3.

**Table 3** Simple regression of CGI, GPAQ-Physical activity, GPAQ-Sedentary behavior and covariates on RAND-36 composite scores

Independent variables	GHC				PHC				MHC			
	B	SE	$t/R^2$	$p$	B	SE	$t/R^2$	$p$	B	SE	$t/R^2$	$p$
CGI-S	-16.573	2.940	0.098	<0.001	-12.480	3.012	0.056	<0.001	-16.878	2.875	0.105	<0.001
GPAQ-Physical	-0.000045	0.002	0.000003	0.976	-0.001	0.002	0.001	0.575	0.000309	0.001	0.000149	0.834
GPAQ-Sedentary	-0.006	0.014	0.001	0.651	-0.010	0.014	0.002	0.478	-0.004	0.014	0.000275	0.776
Age (year)	0.413	0.397	0.004	0.298	-0.419	0.397	0.004	0.292	0.973	0.382	0.022	0.011
Sex	4.107	7.287	0.001	0.573	-0.742	7.299	0.000035	0.919	8.432	7.132	0.005	0.238
Ethnicity			0.009	0.284			0.010	0.226			0.007	0.348
Malay	-15.978	16.934	-0.944	0.346	-26.424	16.940	-1.560	0.120	-7.450	16.721	-0.446	0.656
Indian	15.660	12.929	1.211	0.227	8.258	12.935	0.638	0.524	17.252	12.764	1.352	0.178
Antipsychotic dose*	-0.017	0.009	0.013	0.055	-0.013	0.009	0.008	0.132	-0.018	0.009	0.014	0.040
Education level	5.831	2.572	0.017	0.024	7.289	2.563	0.027	0.005	3.408	2.549	0.006	0.182
Employment status	5.268	7.223	0.002	0.466	1.836	7.237	0.000221	0.800	7.798	7.084	0.004	0.272
Household income	3.370	2.530	0.006	0.184	4.354	2.536	0.011	0.087	2.284	2.480	0.003	0.358
Residence type	-0.391	2.325	0.000097	0.866	1.074	2.327	0.001	0.645	-0.958	2.290	0.001	0.676
Duration of illness	0.207	0.418	0.001	0.621	-0.477	0.418	0.004	0.255	0.562	1.373	0.006	0.171
Duration of treatment	0.261	0.424	0.001	0.538	-0.481	0.424	0.004	0.257	0.655	0.415	0.008	0.115
BMI	-0.861	0.698	0.005	0.219	-1.833	0.693	0.023	0.009	-0.122	0.688	0.000107	0.859
Smoking status			0.026	0.021			0.025	0.025			0.020	0.054
Current smoker	-18.203	11.838	-1.538	0.125	-18.717	11.859	-1.578	0.116	-17.524	11.593	-1.512	0.132
Ex-smoker	-7.231	9.902	-0.730	0.466	-6.149	9.920	-0.620	0.536	-4.264	9.644	-0.442	0.659
Alcohol consumption			0.004	0.601			0.004	0.575			0.005	0.481
Current drinker	-8.997	9.001	-1.000	0.318	-6.654	9.010	-0.739	0.461	-10.221	8.857	-1.154	0.249
Past drinker	-4.132	8.684	-0.476	0.635	-8.304	8.693	-0.955	0.340	-0.357	8.509	-0.042	0.967
Marital Status			0.018	0.266			0.013	0.429			0.033	0.042
Married	-3.875	11.039	-0.351	0.726	-15.272	11.079	-1.379	0.169	4.856	10.802	0.450	0.653
Separated	-51.000	35.799	-1.425	0.155	-38.403	35.928	-1.069	0.286	-51.900	35.050	-1.481	0.140
Divorced	19.940	14.360	1.389	0.166	10.735	14.411	0.745	0.457	22.496	14.055	1.601	0.111
Widowed	35.405	35.799	0.989	0.323	-11.045	35.928	-0.307	0.759	69.718	30.419	2.292	0.023

CGI-S Clinical Global Impression-Severity, GPAQ Global physical activity questionnaire, BMI body mass index

\*Antipsychotic doses were converted into total daily chlorpromazine equivalents

## References

- Valencia, M., Fresán, A., Barak, Y., Juárez, F., Escamilla, R., & Saracco, R. (2015). Predicting functional remission in patients with schizophrenia: A cross-sectional study of symptomatic remission, psychosocial remission, functioning, and clinical outcome. *Neuropsychiatric Disease and Treatment*, *11*, 2339–2348. <https://doi.org/10.2147/NDT.S87335>.
- Coons, S. J., Rao, S., Keininger, D. L., & Hays, R. D. (2000). A comparative review of generic quality-of-life instruments. *Pharmacoeconomics*, *17*(1), 13–35. <https://doi.org/10.2165/00019053-200017010-00002>.
- Boyer, L., Millier, A., Perthame, E., Aballea, S., Auquier, P., & Toumi, M. (2013). Quality of life is predictive of relapse in schizophrenia. *BMC Psychiatry*, *13*(1), 15. <https://doi.org/10.1186/1471-244X-13-15>.
- Lambert, M., Karow, A., Leucht, S., Schimmelmann, B. G., & Naber, D. (2010). Remission in schizophrenia: validity, frequency, predictors, and patients' perspective 5 years later. *Dialogues in clinical neuroscience*, *12*(3), 393–407. Retrieved from <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3181974&tool=pmcentrez&rendertype=abstract>.
- Folsom, D. P., Depp, C., Palmer, B. W., Mausbach, B. T., Golshan, S., Fellows, I., ... Jeste, D. V. (2009). Physical and mental health-related quality of life among older people with schizophrenia. *Schizophrenia Research*, *108*(0), 207–213. <https://doi.org/10.1016/j.schres.2008.12.008>. Physical.
- Xiang, Y.-T., Weng, Y.-Z., Leung, C.-M., Tang, W.-K., & Ungvari, G. S. (2007). Quality of life of Chinese schizophrenia outpatients in Hong Kong: relationship to sociodemographic factors and symptomatology. *The Australian and New Zealand journal of psychiatry*, *41*(5), 442–449. <https://doi.org/10.1080/00048670701261228>.
- Vancampfort, D., Probst, M., Scheewe, T., Maurissen, K., Sweers, K., Knapen, J., & De Hert, M. (2011). Lack of physical activity during leisure time contributes to an impaired health related quality of life in patients with schizophrenia. *Schizophrenia Research*, *129*(2–3), 122–127. <https://doi.org/10.1016/j.schres.2011.03.018>.
- Ojeda, N., Sánchez, P., Peña, J., Elizagárate, E., Yoller, A. B., Gutiérrez-Fraile, M., ... Napal, O. (2012). An explanatory model of quality of life in schizophrenia: The role of processing speed and negative symptoms. *Actas Españolas de Psiquiatría*, *40*(1), 10–18.
- Tas, C., Brown, E., Cubukcuoglu, Z., Aydemir, O., Danaci, A. E., & Brüne, M. (2013). Towards an integrative approach to understanding quality of life in schizophrenia: The role of neurocognition, social cognition, and psychopathology. *Comprehensive Psychiatry*, *54*(3), 262–268. <https://doi.org/10.1016/j.comppsych.2012.08.001>.
- Rocca, P., Montemagni, C., Mingrone, C., Crivelli, B., Sigaufo, M., & Bogetto, F. (2016). A cluster-analytical approach toward real-world outcome in outpatients with stable schizophrenia. *European Psychiatry*, *32*, 48–54. <https://doi.org/10.1016/j.eurpsy.2015.11.007>.
- Gómez, Y. F., Rodríguez, M.Á.A., & López, M. I. G. (2017). Personal and macro-systemic factors as predictors of quality of life in chronic schizophrenia. *Psicothema*, *29*(2), 160–165. <https://doi.org/10.7334/psicothema2016.179>.
- Vrbova, K., Prasko, J., Ociskova, M., Kamaradova, D., Marackova, M., Holubova, M., ... Latalova, K. (2017). Quality of life, self-stigma, and hope in schizophrenia spectrum disorders: A cross-sectional study. *Neuropsychiatric Disease and Treatment*, *13*, 567–576. <https://doi.org/10.2147/NDT.S122483>.
- Laursen, T. M., Munk-Olsen, T., & Vestergaard, M. (2012). Life expectancy and cardiovascular mortality in persons with schizophrenia. *Current Opinion in Psychiatry*, *25*(2), 83–88. <https://doi.org/10.1097/YCO.0b013e32835035ca>.
- Lawrence, D., Hancock, K. J., & Kisely, S. (2013). The gap in life expectancy from preventable physical illness in psychiatric patients in Western Australia: Retrospective analysis of population based registers. *Bmj*, *346*(1), f2539–f2539. <https://doi.org/10.1136/bmj.f2539>.
- Soundy, A., Wampers, M., Probst, M., De Hert, M., Stubbs, B., Vancampfort, D., ... Ströhle, A. (2013). Physical activity and sedentary behaviour in outpatients with schizophrenia: A systematic review and meta-analysis. *International Journal of Therapy and Rehabilitation*, *20*(12), 588–595. <https://doi.org/10.12968/ijtr.2013.20.12.588>.
- Vancampfort, D., Probst, M., Knapen, J., Carraro, A., & De Hert, M. (2012). Associations between sedentary behaviour and metabolic parameters in patients with schizophrenia. *Psychiatry Research*, *200*(2–3), 73–78. <https://doi.org/10.1016/j.psychres.2012.03.046>.
- Strassnig, M., Brar, J. S., & Ganguli, R. (2012). Health-related quality of life, adiposity, and sedentary behavior in patients with early schizophrenia: Preliminary study. *Diabetes, Metabolic Syndrome and Obesity*, *5*, 389–394. <https://doi.org/10.2147/DMSO.S33619>.
- Anokye, N. K., Trueman, P., Green, C., Pavey, T. G., & Taylor, R. S. (2012). Physical activity and health related quality of life. *BMC Public Health*, *12*(1), 624. <https://doi.org/10.1186/1471-2458-12-624>.
- Pucci, G., Reis, R. S., Rech, C. R., & Hallal, P. C. (2012). Quality of life and physical activity among adults: Population-based study in Brazilian adults. *Quality of Life Research*, *21*(9), 1537–1543. <https://doi.org/10.1007/s11136-011-0083-5>.
- Alexandratos, K., Barnett, F., & Thomas, Y. (2012). The impact of exercise on the mental health and quality of life of people with severe mental illness: A critical review. *British Journal of Occupational Therapy*, *75*(2), 48–60. <https://doi.org/10.4276/030802212X13286281650956>.
- Knöchel, C., Oertel-Knöchel, V., O'Dwyer, L., Prvulovic, D., Alves, G., Kollmann, B., & Hampel, H. (2012). Cognitive and behavioural effects of physical exercise in psychiatric patients. *Progress in Neurobiology*, *96*(1), 46–68. <https://doi.org/10.1016/j.pneurobio.2011.11.007>.
- Vera-García, E., Mayoral-Cleries, F., Vancampfort, D., Probst, M., Skjaerven, H., Catalán-Matamoros, L., D., ... De Hert, M. (2012). Systematic review of the benefits of physical therapy within a multidisciplinary care approach for people with schizophrenia. *Physical Therapy*, *92*(1), 11–23. <https://doi.org/10.2522/ptj.20110218>.
- Firth, J., Cotter, J., Elliott, R., French, P., & Yung, A. R. (2015). A systematic review and meta-analysis of exercise interventions in schizophrenia patients. *Psychological Medicine*, *45*(7), 1343–1361. <https://doi.org/10.1017/S0033291714003110>.
- Dauwan, M., Begemann, M. J. H., Heringa, S. M., & Sommer, I. E. (2016). Exercise improves clinical symptoms, quality of life, global functioning, and depression in schizophrenia: A systematic review and meta-analysis. *Schizophrenia Bulletin*, *42*(3), 588–599. <https://doi.org/10.1093/schbul/sbv164>.
- Acil, A. A., Dogan, S., & Dogan, O. (2008). The effects of physical exercises to mental state and quality of life in patients with schizophrenia. *Journal of Psychiatric and Mental Health Nursing*, *15*(10), 808–815. <https://doi.org/10.1111/j.1365-2850.2008.01317.x>.
- Gomes, E., Bastos, T., Probst, M., Ribeiro, J. C., Silva, G., & Corredeira, R. (2014). Effects of a group physical activity

- program on physical fitness and quality of life in individuals with schizophrenia. *Mental Health and Physical Activity*, 7(3), 155–162. <https://doi.org/10.1016/j.mhpa.2014.07.002>.
27. Warren, J. M., Ekelund, U., Besson, H., Mezzani, A., Geladas, N., & Vanhees, L. (2010). Assessment of physical activity: A review of methodologies with reference to epidemiological research: a report of the exercise physiology section of the European Association of Cardiovascular Prevention and Rehabilitation. *European Journal of Cardiovascular Prevention & Rehabilitation*, 17(2), 127–139. <https://doi.org/10.1097/HJR.0b013e32832ed875>.
  28. Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public health reports (Washington, D.C.: 1974)*, 100(2), 126–131. <https://doi.org/10.2307/20056429>.
  29. Deenik, J., Kruisdijk, F., Tenback, D., Braakman-jansen, A., Taal, E., Hopman-rock, M., ... Harten, P., & Van. (2017). Physical activity and quality of life in long-term hospitalized patients with severe mental illness: a cross-sectional study, 17(1), 1–11. <https://doi.org/10.1186/s12888-017-1466-0>.
  30. McCormick, B. P., Sneath, G., Smith, R. L., & Lysaker, P. H. (2012). Active leisure in the emotional experience of people with schizophrenia. *Therapeutic Recreation Journal*, 46(3), 179–190. <https://doi.org/10.4276/030802212X13286281651036>
  31. Bonsaksen, T., & Lerdal, A. (2012). Relationships between physical activity, symptoms and quality of life among inpatients with severe mental illness. *British Journal of Occupational Therapy*, 75(2), 69–75. .
  32. Hebestreit, H., Schmid, K., Kieser, S., Junge, S., Ballmann, M., Roth, K., ... Kriemler, S. (2014). Quality of life is associated with physical activity and fitness in cystic fibrosis. *BMC Pulmonary Medicine*, 14(1), 26 <https://doi.org/10.1186/1471-2466-14-26>.
  33. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. Position stand of the American College of Sports Medicine. (1993). *Schweizerische Zeitschrift fur Sportmedizin*, 41(3), 127–137.
  34. Martin, C. K., Church, T. S., Thompson, A. M., Earnest, C. P., & Blair, S. N. (2009). Exercise dose and quality of life: A randomized controlled trial. *Archives of Internal Medicine*, 169(3), 269. <https://doi.org/10.1001/archinternmed.2008.545>.
  35. Brown, D. W., Brown, D. R., Heath, G. W., Balluz, L., Giles, W. H., Ford, E. S., & Mokdad, A. H. (2004). Associations between physical activity dose and health-related quality of life. *Medicine & Science in Sports & Exercise*, 890–896. <https://doi.org/10.1249/01.MSS.0000126778.77049.76>.
  36. Kerling, A., Tegtbur, U., Ziegenbein, M., Grams, L., Heinze, D. R., & Sieberer, M. (2013). Exercise capacity and quality of life in patients with schizophrenia. *Psychiatric Quarterly*, 84(4), 417–427. <https://doi.org/10.1007/s1126-013-9256-4>.
  37. Packer, S., Husted, J., Cohen, S., & Tomlinson, G. (1997). Psychopathology and quality of life in schizophrenia. *Journal of Psychiatry and Neuroscience*, 22(4), 231–234.
  38. Savilla, K., Kettler, L., & Galletly, C. (2008). Symptoms and quality of life in schizophrenia. *Australian and New Zealand Journal of Psychiatry*, 42, 496–504. <https://doi.org/10.1080/00048670802050512.Relationships>.
  39. Browne, S., Clarke, M., Gervin, M., Waddington, J. L., Larkin, C., & Callaghan, E. O. (2014). Determinants of quality of life at first presentation with schizophrenia, 173–176. <https://doi.org/10.1192/bjpp.176.2.173>.
  40. Chugh, P. K., Rehan, H. S., Unni, K. E. S., & Sah, R. K. (2013). Predictive value of symptoms for quality of life in first-episode schizophrenia. *Nordic Journal of Psychiatry*, 67(3), 153–158. <https://doi.org/10.3109/08039488.2012.687768>.
  41. RITSNER, M. (2003). Predicting changes in domain-specific quality of life of schizophrenia patients. *The Journal of Nervous and Mental Disease*, 191(5), 287–294. <https://doi.org/10.1097/01.NMD.0000066150.38204.F6>.
  42. Priebe, S., McCabe, R., Junghan, U., Kallert, T., Ruggeri, M., Slade, M., & Reininghaus, U. (2011). Association between symptoms and quality of life in patients with schizophrenia: A pooled analysis of changes over time. *Schizophrenia Research*, 133(1–3), 17–21. <https://doi.org/10.1016/j.schres.2011.09.021>.
  43. Ritsner, M., Gibel, A., & Ratner, Y. (2006). Determinants of changes in perceived quality of life in the course of schizophrenia. *Quality of Life Research*, 15(3), 515–526. <https://doi.org/10.1007/s11136-005-2808-9>.
  44. Vancampfort, D., Guelinckx, H., Probst, M., Stubbs, B., Rosenbaum, S., Ward, P. B., & De Hert, M. (2015). Health-related quality of life and aerobic fitness in people with schizophrenia. *International Journal of Mental Health Nursing*, 24(5), 394–402. <https://doi.org/10.1111/inm.12145>.
  45. Guy, W. (1976). Clinical global impressions. In ECDEU Assessment Manual for Psychopharmacology, revised (pp. 217–222). Rockville: US Department of Health, Education, and Welfare Public Health Service Alcohol, Drug Abuse, and Mental Health Administration.
  46. Mortimer, A. M. (2007). Symptom rating scales and outcome in schizophrenia. *The British journal of psychiatry. Supplement*, 50, s7–14.
  47. Leucht, S., & Engel, R. R. (2006). The relative sensitivity of the clinical global impressions scale and the brief psychiatric rating scale in antipsychotic drug trials. *Neuropsychopharmacology*, 31(2) 406–412. <https://doi.org/10.1038/sj.npp.1300873>.
  48. World Health Organization. (2012). Global physical activity surveillance. Retrieved from <http://www.who.int/ncds/surveillance/steps/GPAQ/en/>.
  49. Misra, P., Upadhyay, R. P., Krishnan, A., Sharma, N., & Kapoor, S. K. (2014). A community based study to test the reliability and validity of physical activity measurement techniques. *International Journal of Preventive Medicine*, 5(8), 952–959.
  50. Lingesh, G., Khoo, S., Nahar, M., Mohamed, A., Taib, N. A., & Group, A. M. (2016). Comparing physical activity levels of Malay version of the IPAQ and GPAQ with accelerometer in nurses. *International Journal of Applied Exercise Physiology*, 5(3), 9–17. Retrieved from [https://umexpert.um.edu.my/file/publication/00004688\\_142708.pdf](https://umexpert.um.edu.my/file/publication/00004688_142708.pdf).
  51. Bull, F. C., Maslin, T. S., & Armstrong, T. (2009). Global Physical Activity Questionnaire (GPAQ): Nine country reliability and validity study. *Journal of Physical Activity and Health*, 6(6), 790–804. <https://doi.org/10.1123/jpah.6.6.790>.
  52. Faulkner, G., Cohn, T., & Remington, G. (2006). Validation of a physical activity assessment tool for individuals with schizophrenia, 82, 225–231. <https://doi.org/10.1016/j.schres.2005.10.020>.
  53. Duncan, M. J., Arbour-nicitopoulos, K., Subramaniepillai, M., Remington, G., & Faulkner, G. (2017). Revisiting the International Physical Activity Questionnaire (IPAQ): Assessing physical activity among individuals with schizophrenia. *Schizophrenia Research*, 179, 2–7. <https://doi.org/10.1016/j.schres.2016.09.010>.
  54. Trinh, O. T. H., Nguyen, N., Do, van der Ploeg, H. P., Dibley, M. J., & Bauman, A. (2009). Test-retest repeatability and relative validity of the Global Physical Activity Questionnaire in a developing country context. *Journal of Physical Activity and Health*, 6(s1), S46–S53. <https://doi.org/10.1123/jpah.6.s1.s46>.
  55. Chu, A. H. Y., Ng, S. H. X., Koh, D., Müller-Riemenschneider, F., & Brucki, S. (2015). Reliability and validity of the self- and interviewer-administered versions of the Global Physical Activity Questionnaire (GPAQ). *PLoS ONE*, 10(9), 1–18. <https://doi.org/10.1371/journal.pone.0136944>.

56. World Health Organization. (2010). *Global Physical Activity Questionnaire*, 380(9838), 282–293. [https://doi.org/10.1016/S0140-6736\(12\)60736-3](https://doi.org/10.1016/S0140-6736(12)60736-3).The.
57. Win, A. M., Yen, L. W., Tan, K. H., Lim, R. B. T., Chia, K. S., & Mueller-Riemenschneider, F. (2015). Patterns of physical activity and sedentary behavior in a representative sample of a multi-ethnic South-East Asian population: A cross-sectional study. *BMC Public Health*, 15(1), 1–11. <https://doi.org/10.1186/s12889-015-1668-7>.
58. Hays, R. D., & Morales, L. S. (2001). The RAND-36 measure of health-related quality of life. *Annals of Medicine*, 33(5), 350–357. <https://doi.org/10.3109/07853890109002089>.
59. Hays, R. D., Prince-Embury, S., & Chen, H.-Y. (1998). *RAND-36 health status inventory*. San Antonio: The Psychological Corporation.
60. Papaioannou, D., Brazier, J., & Parry, G. (2011). How valid and responsive are generic health status measures, such as EQ-5D and SF-36, in Schizophrenia? A systematic review. *Value in Health*, 14(6), 907–920. <https://doi.org/10.1016/j.jval.2011.04.006>.
61. Coons, S. J., Alabdulmohsin, S. A., Draugalis, J. R., & Hays, R. D. (1998). Reliability of an Arabic version of the RAND-36 Health Survey and its equivalence to the US-English version. *Medical care*, 36(3), 428–432. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/9520966>.
62. Moorer, P., Suurmeijer, T. P. B. M., Foets, M., & Molenaar, I. W. (2001). Psychometric properties of the RAND-36 among three chronic diseases (multiple sclerosis, rheumatic diseases and COPD) in the Netherlands. *Quality of Life Research*, 10(7), 637–645. <https://doi.org/10.1023/A:1013131617125>.
63. Picavet, H. S. J., & Hoeymans, N. (2004). Health related quality of life in multiple musculoskeletal diseases: SF-36 and EQ-5D in the DMC3 study. *Annals of the Rheumatic Diseases*, 63(6), 723–729. <https://doi.org/10.1136/ard.2003.010769>.
64. Aaronson, N. K., Muller, M., Cohen, P. D. A., Essink-Bot, M. L., Fekkes, M., Sanderman, R., ... Verrips, E. (1998). Translation, validation, and norming of the Dutch language version of the SF-36 Health Survey in community and chronic disease populations. *Journal of Clinical Epidemiology*, 51(11), 1055–1068. [https://doi.org/10.1016/S0895-4356\(98\)00097-3](https://doi.org/10.1016/S0895-4356(98)00097-3).
65. Jenkinson, C., Coulter, A., & Wright, L. (1993). Short form 36 (SF 36) health survey questionnaire: Normative data for adults of working age. *British Medical Journal*, 306(Sf 36), 1437–1440.
66. Su, C.-T., Ng, H.-S., Yang, A.-L., & Lin, C.-Y. (2014). Psychometric evaluation of the Short Form 36 Health Survey (SF-36) and the World Health Organization Quality of Life Scale Brief Version (WHOQOL-BREF) for patients with schizophrenia. *Psychological Assessment*, 26(3), 980–989. <https://doi.org/10.1037/a0036764>.
67. Dexter, P. R., Stump, T. E., Tierney, W. M., & Wolinsky, F. D. (1996). The psychometric properties of the SF-36 health survey among older adults in a clinical setting. *Journal of Clinical Geropsychology*, 2(3), 225–237. Retrieved from <http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=1997-43622-007&site=ehost-live>.
68. Nortvedt, M. W., Riise, T., Myhr, K.-M., & Nyland, H. I. (2000). Performance of the SF-36, SF-12, and RAND-36 summary scales in a multiple sclerosis population. *Medical Care*, 38(10). Retrieved from [https://journals.lww.com/lww-medicalcare/Fulltext/2000/10000/Performance\\_of\\_the\\_SF\\_36\\_SF\\_12\\_and\\_RAND\\_36.6.aspx](https://journals.lww.com/lww-medicalcare/Fulltext/2000/10000/Performance_of_the_SF_36_SF_12_and_RAND_36.6.aspx).
69. Selya, A. S., Rose, J. S., Dierker, L. C., Hedeker, D., & Mermelstein, R. J. (2012). A practical guide to calculating Cohen's  $f^2$ , a measure of local effect size, from PROC MIXED. *Frontiers in Psychology*, 3(APR), 1–6. <https://doi.org/10.3389/fpsyg.2012.00111>.
70. Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale: L. Erlbaum Associates.
71. Browne, S., Clarke, M., Gervin, M., Waddington, J. L., Larkin, C., & Callaghan, E. O. (2014). Determinants of quality of life at first presentation with schizophrenia determinants of quality of life at first presentation with schizophrenia. *The British Journal of Psychiatry*, 176(2) 173–176. <https://doi.org/10.1192/bjp.176.2.173>.
72. Sugawara, N., Yasui-furukori, N., Sato, Y., Saito, M., Furukori, H., & Nakagami, T. (2013). Body mass index and quality of life among outpatients with schizophrenia in Japan. *BMC psychiatry*, 13, 108. <https://doi.org/10.1186/1471-244X-13-108>.
73. Le Pen, C., Lévy, E., Loos, F., Banzet, M. N., & Basdevant, A. (1998). “Specific” scale compared with “generic” scale: A double measurement of the quality of life in a French community sample of obese subjects. *Journal of Epidemiology and Community Health*, 52(7), 445–450. <https://doi.org/10.1136/jech.52.7.445>.
74. Doll, H. A., Petersen, S. E. K., & Stewart-Brown, S. L. (2000). Obesity and physical and emotional well-being: Associations between body mass index, chronic illness, and the physical and mental components of the SF-36 questionnaire. *Obesity Research*, 8(2), 160–170. <https://doi.org/10.1038/oby.2000.17>.
75. Faulkner, G., Cohn, T., Remington, G., & Irving, H. (2007). Body mass index, waist circumference and quality of life in individuals with schizophrenia. *Schizophrenia Research*, 90(1–3), 174–178. Retrieved from <http://search.ebscohost.com/login.aspx?direct=true&db=cmedm&AN=17140768&site=ehost-live>.
76. Tan, H. Y., Choo, W. C., Doshi, S., Lim, L. E. C., & Kua, E. H. (2004). A community study of the health-related quality of life of schizophrenia and general practice outpatients in Singapore. *Social Psychiatry and Psychiatric Epidemiology*, 39(2), 106–112. <https://doi.org/10.1007/s00127-004-0717-9>.
77. Eklund, M. (2009). Work status, daily activities and quality of life among people with severe mental illness. *Quality of Life Research*, 18(2), 163–170. <https://doi.org/10.1007/s11136-008-9431-5>.
78. Vancampfort, D., Probst, M., De Hert, M., Soundy, A., Stubbs, B., Stroobants, M., & De Herdt, A. (2014). Neurobiological effects of physical exercise in schizophrenia: A systematic review. *Disability and Rehabilitation*, 36(21), 1749–1754. <https://doi.org/10.3109/09638288.2013.874505>.
79. Stubbs, B., Firth, J., Berry, A., Schuch, F. B., Rosenbaum, S., Gaughran, F., ... Vancampfort, D. (2016). How much physical activity do people with schizophrenia engage in? A systematic review, comparative meta-analysis and meta-regression. *Schizophrenia Research*, 176(2–3), 431–440. <https://doi.org/10.1016/j.schres.2016.05.017>.
80. Samitz, G., Egger, M., & Zwahlen, M. (2011). Domains of physical activity and all-cause mortality: Systematic review and dose-response meta-analysis of cohort studies. *International Journal of Epidemiology*, 40(5), 1382–1400. <https://doi.org/10.1093/ije/dyr112>.
81. Matthews, C. E., Jurj, A. L., Shu, X.-O., Li, H.-L., Yang, G., Li, Q., ... Zheng, W. (2007). Influence of exercise, walking, cycling, and overall nonexercise physical activity on mortality in Chinese women. *American Journal of Epidemiology*, 165(12), 1343–1350. <https://doi.org/10.1093/aje/kwm088>.
82. Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, 18(2). Retrieved from [https://journals.lww.com/co-psychiatry/Fulltext/2005/03000/Exercise\\_and\\_well\\_being\\_a\\_review\\_of\\_mental\\_and.13.aspx](https://journals.lww.com/co-psychiatry/Fulltext/2005/03000/Exercise_and_well_being_a_review_of_mental_and.13.aspx).

83. Vancampfort, D., Knapen, J., Probst, M., Scheewe, T., Remans, S., & De Hert, M. (2012). A systematic review of correlates of physical activity in patients with schizophrenia. *Acta Psychiatrica Scandinavica*, *125*(5), 352–362. <https://doi.org/10.1111/j.1600-0447.2011.01814.x>.
84. Yamauchi, K., Aki, H., Tomotake, M., Iga, J., Numata, S., Motoki, I., ... Ohmori, T. (2008). Predictors of subjective and objective quality of life in outpatients with schizophrenia. *Psychiatry and Clinical Neurosciences*, *62*, 404–411. <https://doi.org/10.1016/j.psychres.2006.05.017>.
85. Vancampfort, D., De Hert, M., Vansteenkiste, M., De Herdt, A., Scheewe, T. W., Soundy, A., ... Probst, M. (2013). The importance of self-determined motivation towards physical activity in patients with schizophrenia. *Psychiatry Research*, *210*(3), 812–818. <https://doi.org/10.1016/j.psychres.2013.10.004>.
86. Eklund, M., & Leufstadius, C. (2007). Relationships between occupational factors and health and well-being in individuals with persistent mental illness living in the community. *Canadian Journal of Occupational Therapy*, *74*(4), 303–313. <https://doi.org/10.1177/000841740707400403>.
87. Eklund, M., & Bäckström, M. (2005). A model of subjective quality of life for outpatients with schizophrenia and other psychoses. *Quality of Life Research*, *14*(4), 1157–1168. <https://doi.org/10.1007/s11136-004-2960-7>.
88. Motl, R. W., McAuley, E., Wynn, D., Sandroff, B., & Suh, Y. (2013). Physical activity, self-efficacy, and health-related quality of life in persons with multiple sclerosis: Analysis of associations between individual-level changes over one year. *Quality of Life Research*, *22*(2), 253–261. <https://doi.org/10.1007/s11136-012-0149-z>.
89. McAuley, E., Doerksen, S. E., Morris, K. S., Motl, R. W., Hu, L., Wójcicki, T. R., ... Rosengren, K. R. (2008). Pathways from physical activity to quality of life in older women. *Annals of Behavioral Medicine*, *36*(1), 13–20. <https://doi.org/10.1007/s12160-008-9036-9>.
90. McAuley, E., Konopack, J. F., Motl, R. W., Morris, K. S., Doerksen, S. E., & Rosengren, K. R. (2006). Physical activity and quality of life in older adults: Influence of health status and self-efficacy. *Annals of Behavioral Medicine*, *31*(1), 99–103. [https://doi.org/10.1207/s15324796abm3101\\_14](https://doi.org/10.1207/s15324796abm3101_14).
91. Rezaie, L., Shafaroodi, N., & Philips, D. (2017). The barriers to participation in leisure time physical activities among Iranian women with severe mental illness: A qualitative study. *Mental Health and Physical Activity*, *13*, 171–177. <https://doi.org/10.1016/j.mhpa.2017.09.008>.
92. Saris, W. H. M., Blair, S. N., van Baak, M. A., Eaton, S. B., Davies, P. S. W., Di Pietro, L., ... Wyatt, H. (2003). How much physical activity is enough to prevent unhealthy weight gain? Outcome of the IASO 1st Stock Conference and consensus statement. *Obesity reviews: an official journal of the International Association for the Study of Obesity*, *4*(2), 101–114. <https://doi.org/10.1046/j.1467-789X.2003.00101.x>.
93. Shephard, R. J. (2003). Limits to the measurement of habitual physical activity by questionnaires. *British Journal of Sports Medicine*, *37*(3), 197–206. <https://doi.org/10.1136/bjism.37.3.197>.
94. Altschuler, A., Picchi, T., Nelson, M., Rogers, J. D., Hart, J., & Sternfeld, B. (2009). Physical activity questionnaire comprehension-lessons from cognitive interviews. *Medicine & Science in Sports & Exercise*, *41*(2), 336–343. <https://doi.org/10.1002/nbm.3066>. Non-invasive.
95. Keefe, R. S. E., & Harvey, P. D. (2012). Cognitive impairment in schizophrenia. In M. A. Geyer, & G. Gross (Eds.), *Handbook of experimental pharmacology: Vol. 213. Novel antischizophrenia treatments* (pp. 11–37). Berlin, Heidelberg: Springer. <https://doi.org/10.1007/978-3-642-25758-2>.
96. Cleland, C. L., Hunter, R. F., Kee, F., Cupples, M. E., Sallis, J. F., & Tully, M. A. (2014). Validity of the Global Physical Activity Questionnaire (GPAQ) in assessing levels and change in moderate-vigorous physical activity and sedentary behaviour. *BMC Public Health*, *14*(1), 1255. <https://doi.org/10.1186/1471-2458-14-1255>.
97. Prince, S. A., Adamo, K. B., Hamel, M., Hardt, J., Gorber, C., S., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *5*(1), 56. <https://doi.org/10.1186/1479-5868-5-56>.
98. Alkahtani, S. A. (2016). Convergent validity: Agreement between accelerometry and the Global Physical Activity Questionnaire in college-age Saudi men. *BMC Research Notes*, *9*(1), 436. <https://doi.org/10.1186/s13104-016-2242-9>.
99. Pate, R. R., O'Neill, J. R., & Lobelo, F. (2008). The evolving definition of “Sedentary”. *Exercise and Sport Sciences Reviews*, *36*(4), 173–178. <https://doi.org/10.1097/JES.0b013e3181877d1a>.
100. Hayhurst, K. P., Massie, J. A., Dunn, G., Lewis, S. W., & Drake, R. J. (2014). Validity of subjective versus objective quality of life assessment in people with schizophrenia. *BMC Psychiatry*, *14*(1), 1–8. <https://doi.org/10.1186/s12888-014-0365-x>.
101. Bobes, J., García-Portilla, P., Sáiz, P. A., Bascarán, T., & Bousño, M. (2005). Quality of life measures in schizophrenia. *European Psychiatry*, *20*, 1–8. [https://doi.org/10.1016/S0924-9338\(05\)80182-8](https://doi.org/10.1016/S0924-9338(05)80182-8).
102. Voruganti, L., Heslegrave, R., Awad, A. G., & Seeman, M. V. (1998). Quality of life measurement in schizophrenia: Reconciling the quest for subjectivity with the question of reliability. *Psychological Medicine*, *28*(1), 165–172. <https://doi.org/10.1017/S0033291797005874>.
103. Pinikahana, J., Happell, B., Hope, J., & Keks, N. a. (2002). Quality of life in schizophrenia: A review of the literature from 1995 to 2000. *International Journal of Mental Health Nursing*, *11*(2), 103–111. <https://doi.org/10.1046/j.1440-0979.2002.00233.x>.

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