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Physical Activity and Body Mass Index (BMI) as Predictors of Health-related Quality of Life in Montana Adults

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Abstract **Background**: Health-related quality of life (HRQOL) is an important concept related to how health status affects a person's life. Engaging in physical activity (PA) and maintaining healthy body weight are each linked to favorable HRQOL. However, the extent to which PA and body weight independently influence HRQOL is less known. The aim of this research was to examine how meeting PA guidelines and body mass index (BMI) affect a measure of HRQOL in adults. **Methods**: The Montana Behavioral Risk Factor Surveillance System (BRFSS, 2019) was used for this study. Three different PA guideline variables were used and included a two-level aerobic PA (APA) (met APA or did not meet APA) measure, a two-level muscle strengthening activity (MSA) (met MSA or did not meet MSA) measure, and a two-level PA guidelines (APA/MSA) (met both APA and MSA or did not meet both) measure. BMI was calculated from self-reported height and weight (kg/m^2). HRQOL was assessed from a question asking participants to rate their general health with the following response options: "excellent", "very good", "good", "fair" or "poor". Multinomial logistic regression was used to examine the independent effects of PA and BMI on each HRQOL rating (relative to excellent) while controlling for sociodemographic variables. **Results**: Differences in HRQOL prevalence was seen within all sociodemographic variables except sex. Additionally, BMI was significantly (p < .05) greater in adults reporting fair or poor health (*Mean* = 30.30, *SE* = 0.32) compared to those reporting excellent, very good or good health (*Mean* = 27.28, *SE* = 0.09), with a similar trend seen across all sociodemographic groups. The fully adjusted regression model including APA/MSA showed decreased odds of very good (OR = 0.75, 95% CI: 0.60 – 0.92), good (OR = 0.61, 95% CI: 0.49 – 0.78), fair (OR = 0.56, 95% CI: 0.40 – 0.78), and poor health (OR = 0.44, 95% CI: 0.28 – 0.69) (relative to excellent health) for adults meeting both APA and MSA. In the same model, increased odds was seen for very good (OR = 1.08, 95% CI: 1.06 – 1.10), good (OR = 1.15, 95% CI: 1.13 – 1.18), fair (OR = 1.19, 95% CI: 1.16 – 1.23), and poor health (OR = 1.16, 95% CI: 1.12 – 1.21) (relative to excellent health) for each 1-unit increase in BMI (1.00 kg/m^2). Similar findings were seen in the separate APA model but not the MSA model. **Conclusion**: This study found that meeting PA guidelines and BMI were both independently related to HRQOL in adults. However, meeting MSA showed lower effects and inconsistent effects on HRQOL. Health promotion specialists concerned with improving HRQOL should promote both APA and MSA guidelines along with healthy body weight behavior. Physical activity programming should consider APA a priority over MSA for improving HRQOL in Montana adults.

Keywords: *body mass index (BMI), physical activity (PA), muscle strengthening activity (MSA), health-related quality of life (HRQOL)*

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1. Introduction

Health-related quality of life (HRQOL) is a commonly used outcome measure in both population-based and clinical-based research [1-6]. From January 2020 to October 2021, over 9,500 articles using the phrase "health-related quality of life" have been indexed in the PUBMED database, accounting for almost 20% of the total articles on the topic since 1982. More specifically, HRQOL is a subjective multidimensional concept that extends beyond objective measures of health-status by measuring the extent to which health can affect the quality of a person's life [7]. Physical activity (PA) is a health behavior known to positively influence HRQIL in adults [8,9]. Additionally, muscle strengthening activity (MSA), a specific form of PA, is known to improve HRQOL when used as an intervention component in adults [10]. Obesity is a major health problem worldwide and is strongly

associated with the modifiable behaviors of poor diet and physical inactivity [11]. As expected, HRQOL is also associated with obesity with obese populations more likely reporting poor health than normal weight counterparts [12,13]. Given these clear associations linking both PA and obesity to HRQOL, it is unclear the extent to which PA and obesity measures independently influence HRQOL in adult populations. Therefore, the aim of this research was to examine how meeting PA guidelines and body mass index (BMI) affect a measure of HRQOL in adults.

2. Materials & Methods

Data for this study came from the 2019 Montana Behavioral Risk Factor Surveillance System (BRFSS). BRFSS methodological details can be found elsewhere [14,15]. The BRFSS is a state-based annual telephone survey aimed at collecting data about health factors related to the leading causes of premature morbidity and mortality. The BRFSS samples noninstitutionalized U.S. adults 18+ years of age. The Montana BRFSS data were extracted from the larger dataset for this study.

Three different PA guideline variables were used in this study. A two-level aerobic PA (APA) variable was constructed and participants were classified as either those that "met APA" or "did not meet APA" guidelines. A two-level muscle strengthening activity (MSA) variable was constructed and participants were classified as either those that "met MSA" or "did not meet MSA" guidelines. A final two-level PA variable was constructed and participants were classified as either those that "met both APA and MSA" or "met neither" guideline. Meeting APA was determined from a series of questions asking participants about their PA and exercise during the previous month. After reporting the types of activities, the usual frequency, and usual duration, a total minutes of PA per week was computed for each respondent. Those reporting 150+ minutes of total PA per week were considered those that "met APA" guidelines. Those reporting less than 150 minutes of total PA per week were considered those that "did not meet APA" guidelines [16].

Meeting MSA was determined from a series of questions asking participants about their muscle strengthening PA and exercise during the previous month. Participants reporting 2+ days per week of MSA were considered those that "met MSA" guidelines and participants reporting less than 2 days per week were considered those that "did not meet MSA" guidelines [17]. BMI was calculated from self-reported height and weight (kg/m^2). HRQOL was assessed from a question asking participants to rate their general health with the following response options: "excellent", "very good", "good", "fair" or "poor". Study covariates included sex, age, race/ethnicity, income, education, and rural/urban status.

Statistical analyses included prevalence estimates (%) and standard errors (SEs) for HRQOL groups across sociodemographic characteristics. Also, means and SEs were computed for BMI (kg/m^2) by HRQOL groups and across sociodemographic variables. APA and MSA parameter status. Test for difference in prevalence estimates and means were performed using the Rao-Scott chi-square (χ^2_{RS}) test of independence and regression analysis t statistic, respectively. The proportional odds assumption was violated (χ^2 = 11,831.8, p < .0001) for HRQOL which lead to a generalized logit model. Multinomial logistic regression was then used to examine the independent effects of PA and BMI on each HRQOL rating relative to excellent health. Odds ratios (ORs) and 95% confidence intervals (CIs) were reported to evaluate predictor variables. Fully adjusted regression models were controlled for sex, age, race/ethnicity, income, education, and rural/urban status. Analyses were weighted to produce generalizations representative of noninstitutionalized adults in Montana. SAS version 9.4 and SPSS version 27 were used for all analyses [18,19,20,21].

3. Results

Overall, a total of N = 6,477 participants had complete HRQOL data with an 84.8% (95% CI: 83.7% – 85.8%) prevalence of good HRQOL (excellent or very good, or good) and a 15.2% (95% CI: 14.2% – 16.3%) prevalence of poor HRQOL (fair or poor). Table 1 contains these prevalence estimates across pertinent sociodemographic variables. Most notably, sex difference in HRQOL estimates were not significant (p = .7502). However, older adult, American Indian and Multiracial, lower income, less educated, and rural groups all trended toward higher rates of poor health, compared to their respective counterparts (all ps < .05). Table 2 contains BMI comparison by HRQOL status across the same sociodemographic variables. Overall, BMI was significantly (p < .0001) lower in good HRQOL (*Mean* = 27.28, *SE* = 0.09) as compared to poor HRQOL (*Mean* = 30.30, *SE* = 0.32). Similar significant differences were seen across all sociodemographic groups with the largest HRQOL-related BMI differences seen in young adulthood (25 to 34 yr) and middle age (45 to 54 yr) and Hispanic and Multiracial. Table 3 contains unadjusted multinomial logistic regression models for PA and BMI predicting HRQOL. PA and BMI was significantly related to all general health categories for APA, MSA, and both APA/MSA models.

Table 4 contains the adjusted multinomial logistic regression models for PA and BMI predicting HRQOL. These results indicate that PA and BMI significantly relate to all general health categories in APA and APA/MSA models only. For example, the fully adjusted regression model including APA/MSA showed decreased odds of very good (OR = 0.75, 95% CI: 0.60 – 0.92), good (OR = 0.61, 95% CI: 0.49 – 0.78), fair (OR = 0.56, 95% CI: 0.40 – 0.78), and poor health (OR = 0.44, 95% CI: 0.28 – 0.69) (relative to excellent health) for adults meeting both APA and MSA. In the same model, increased odds was seen for very good (OR = 1.08, 95% CI: 1.06 – 1.10), good (OR = 1.15, 95% CI: 1.13 – 1.18), fair (OR = 1.19, 95% CI: 1.16 – 1.23), and poor health (OR = 1.16, 95% CI: 1.12 – 1.21) (relative to excellent health) for each 1-unit increase in BMI (1.00 kg/m^2). In the MSA model, odds of very good health (relative to excellent health), odds of fair health (relative to excellent health), and odds of poor health (relative to excellent health) were not significantly different for those meeting MSA guidelines. This left a decreased odds of good health

(OR = 0.68, 95% CI: 0.55 – 0.85), relative to excellent health, for adults meeting MSA.

Table 1. Distribution of general health status by sociodemographic characteristic in Montana adults, 2019

	Would you say that in general your health is:						
	Excellent or Very good, or Good			Fair or Poor			χ^2_{RS}
Sociodemographic variable	*N*	*%*	*SE*	*N*	*%*	*SE*	*p*
Overall	5,374	84.8	0.53	1,103	15.2	0.53	< .0001
Sex							.7502
Females	2,713	84.6	0.75	584	15.4	0.75	
Males	2,661	84.9	0.75	519	15.1	0.75	
Age Group (yr)							< .0001
18 to 24	388	93.0	1.39	31	7.0	1.39	
25 to 34	599	90.7	1.29	59	9.3	1.29	
35 to 44	677	86.9	1.36	104	13.1	1.36	
45 to 54	656	83.0	1.62	131	17.0	1.62	
55 to 64	1,096	80.9	1.27	270	19.1	1.27	
65+	1,958	79.4	0.99	508	20.6	0.99	
Race/Ethnicity							< .0001
White	4,621	85.7	0.55	851	14.3	0.55	
American Indian	345	74.2	2.77	147	25.8	2.77	
Hispanic	111	82.6	3.87	28	17.4	3.87	
Multiracial	132	79.3	3.87	41	20.7	3.87	
Income ($)							< .0001
<15,000	266	61.3	2.84	214	38.7	2.84	
15,000 to 24,999	628	74.7	1.76	245	25.3	1.76	
25,000 to 34,999	525	86.2	1.60	102	13.8	1.60	
35,000 to 49,999	747	86.3	1.46	130	13.7	1.46	
50,000+	2,412	92.5	0.59	227.00	7.5	0.59	
Education							< .0001
Did not graduate high school	224	71.1	2.99	99	28.9	2.99	
Graduated high school	1,378	81.7	1.03	391	18.3	1.03	
Attended some college	1,647	84.9	0.92	367	15.1	0.92	
Graduated college	2,111	91.8	0.61	243	8.2	0.61	
Rural Status							.0283
Urban	2,903	85.6	0.67	532	14.4	0.67	
Rural	2,471	83.2	0.87	571	16.8	0.87	

Note. χ^2_{RS} is the Rao-Scott chi-square test of independence.

Table 2. Body mass index (BMI) comparison by general health status across sociodemographic characteristic in Montana adults, 2019

	Would you say that in general your health is:							
	Excellent or Very good, or Good			Fair or Poor			Difference	
Sociodemographic variable	*N*	*Mean*	*SE*	*N*	*Mean*	*SE*	*Mean*	*p*
Overall	5,007	27.28	0.09	1,021	30.30	0.32	3.02	< .0001
Sex								
Females	2,428	27.02	0.15	524	30.31	0.50	3.29	< .0001
Males	2,579	27.52	0.11	497	30.30	0.41	2.78	< .0001
Age Group (yr)								
18 to 24	373	25.38	0.29	26	28.00	1.11	2.62	.0217
25 to 34	560	26.79	0.27	53	31.00	1.04	4.21	< .0001
35 to 44	638	27.37	0.25	100	31.11	0.95	3.73	.0002
45 to 54	596	28.13	0.26	118	32.29	1.14	4.15	.0004
55 to 64	1,011	28.10	0.20	244	30.17	0.63	2.07	.0017
65+	1,829	27.59	0.14	480	29.29	0.42	1.70	.0001
Race/Ethnicity								
White	4,319	27.23	0.10	792	29.95	0.34	2.72	< .0001
American Indian	319	28.77	0.49	135	31.36	0.99	2.59	.0195
Hispanic	102	26.96	0.57	26	33.42	2.41	6.47	.0089
Multiracial	128	27.41	0.64	39	32.37	1.54	4.96	.0030
Income ($)								
<15,000	251	27.42	0.49	200	29.25	0.71	1.83	.0352
15,000 to 24,999	592	27.08	0.31	228	30.90	0.76	3.83	< .0001
25,000 to 34,999	501	27.60	0.28	96	30.32	0.97	2.72	.0070
35,000 to 49,999	709	27.52	0.23	121	31.34	1.14	3.82	.0011
50,000+	2,343	27.32	0.12	219	31.21	0.55	3.89	< .0001
Education								
Did not graduate high school	201	27.76	0.45	87	30.31	1.14	2.56	.0377
Graduated high school	1,272	27.45	0.19	361	30.81	0.58	3.37	< .0001
Attended some college	1,533	27.54	0.17	340	30.14	0.47	2.60	< .0001
Graduated college	1,995	26.74	0.13	231	29.49	0.62	2.75	< .0001
Rural Status								
Urban	2,716	27.05	0.12	489	30.65	0.46	3.60	< .0001
Rural	2,291	27.70	0.15	532	29.79	0.43	2.09	< .0001

Note. Body mass index (BMI) computed from self-reported height and weight (kg/m^2).

Table 3. Unadjusted multinomial logistic regression models for physical activity (PA) and body mass index (BMI) predicting general health in Montana adults, 2019

	APA			MSA			Both APA & MSA		
Ref: Excellent health	*OR*	*LL*	*UL*	*OR*	*LL*	*UL*	*OR*	*LL*	*UL*
Very good health									
PA Guideline									
Met	0.70	0.56	0.86	0.83	0.69	1.00	0.78	0.64	0.95
Did not meet	1.00	Ref		1.00	Ref		1.00	Ref	
BMI	1.08	1.06	1.10	1.08	1.06	1.10	1.08	1.06	1.10
Good health									
PA Guideline									
Met	0.59	0.48	0.74	0.64	0.52	0.78	0.59	0.48	0.74
Did not meet	1.00	Ref		1.00	Ref		1.00	Ref	
BMI	1.16	1.14	1.19	1.16	1.13	1.18	1.16	1.13	1.18
Fair health									
PA Guideline									
Met	0.42	0.32	0.54	0.68	0.52	0.88	0.50	0.38	0.67
Did not meet	1.00	Ref		1.00	Ref		1.00	Ref	
BMI	1.20	1.17	1.23	1.20	1.17	1.23	1.20	1.17	1.23
Poor health									
PA Guideline									
Met	0.20	0.14	0.28	0.55	0.39	0.78	0.35	0.23	0.53
Did not meet	1.00	Ref		1.00	Ref		1.00	Ref	
BMI	1.17	1.13	1.21	1.17	1.13	1.21	1.17	1.13	1.22

Note. Models in this table include both PA and BMI and are not adjusted for other covariates. APA is aerobic physical activity (PA) guidelines. MSA is muscle strengthening activity guidelines. Body mass index (BMI) computed from self-reported height and weight (kg/m^2)

Table 4. Adjusted multinomial logistic regression models for physical activity (PA) and body mass index (BMI) predicting general health in Montana adults, 2019

	APA			MSA			Both APA & MSA		
Ref: Excellent health	*OR*	*LL*	*UL*	*OR*	*LL*	*UL*	*OR*	*LL*	*UL*
Very good health									
PA Guideline									
Met	0.65	0.51	0.81	0.85	0.70	1.05	0.75	0.60	0.92
Did not meet	1.00	Ref		1.00	Ref		1.00	Ref	
BMI	1.08	1.06	1.10	1.08	1.06	1.10	1.08	1.06	1.11
Good health									
PA Guideline									
Met	0.62	0.48	0.79	0.68	0.55	0.85	0.61	0.49	0.78
Did not meet	1.00	Ref		1.00	Ref		1.00	Ref	
BMI	1.15	1.13	1.18	1.15	1.13	1.18	1.15	1.12	1.18
Fair health									
PA Guideline									
Met	0.47	0.35	0.64	0.80	0.60	1.07	0.56	0.40	0.78
Did not meet	1.00	Ref		1.00	Ref		1.00	Ref	
BMI	1.19	1.16	1.23	1.19	1.16	1.23	1.19	1.16	1.23
Poor health									
PA Guideline									
Met	0.26	0.18	0.38	0.69	0.47	1.02	0.44	0.28	0.69
Did not meet	1.00	Ref		1.00	Ref		1.00	Ref	
BMI	1.16	1.12	1.21	1.16	1.12	1.21	1.16	1.12	1.21

Note. Models in this table include both PA and BMI and are adjusted for age, sex, race/ethnicity, income, education, and urban/rural status. APA is aerobic physical activity (PA) guidelines. MSA is muscle strengthening activity guidelines. Body mass index (BMI) computed from self-reported height and weight (kg/m^2)

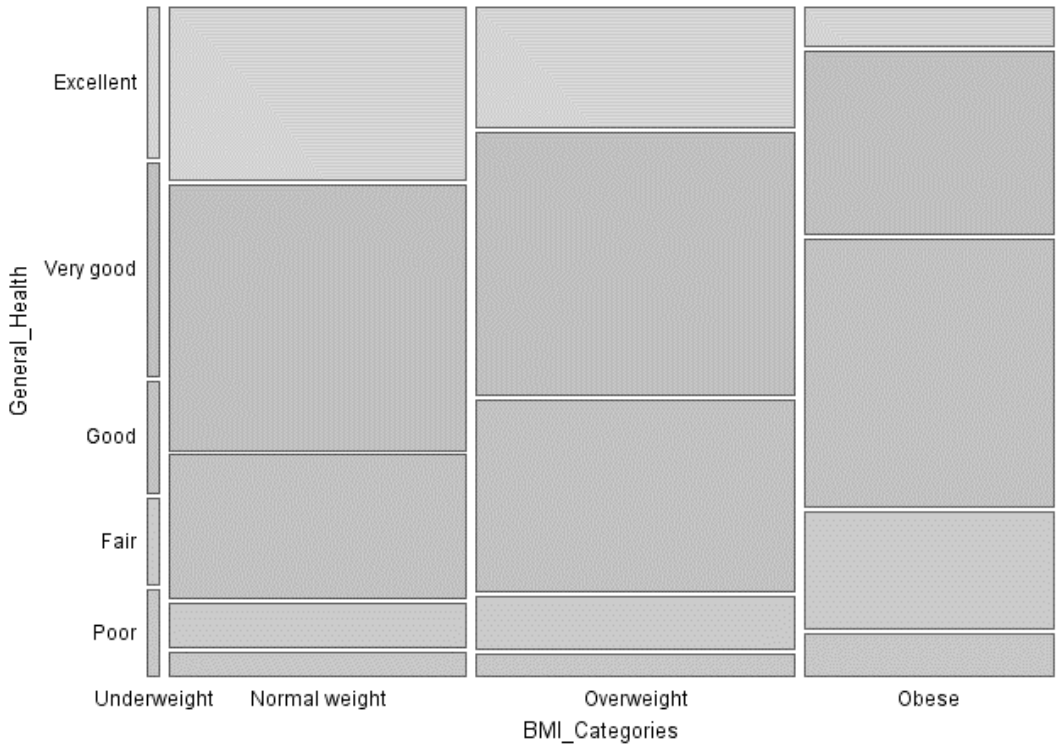

Figure 1. Mosaic plot displaying the distribution of general health by BMI categories in Montana adults, 2019 (Note. N = 6,028. χ^2_{RS} = 395.3, p < .0001. Body mass index (BMI) computed from self-reported height and weight (kg/m^2))

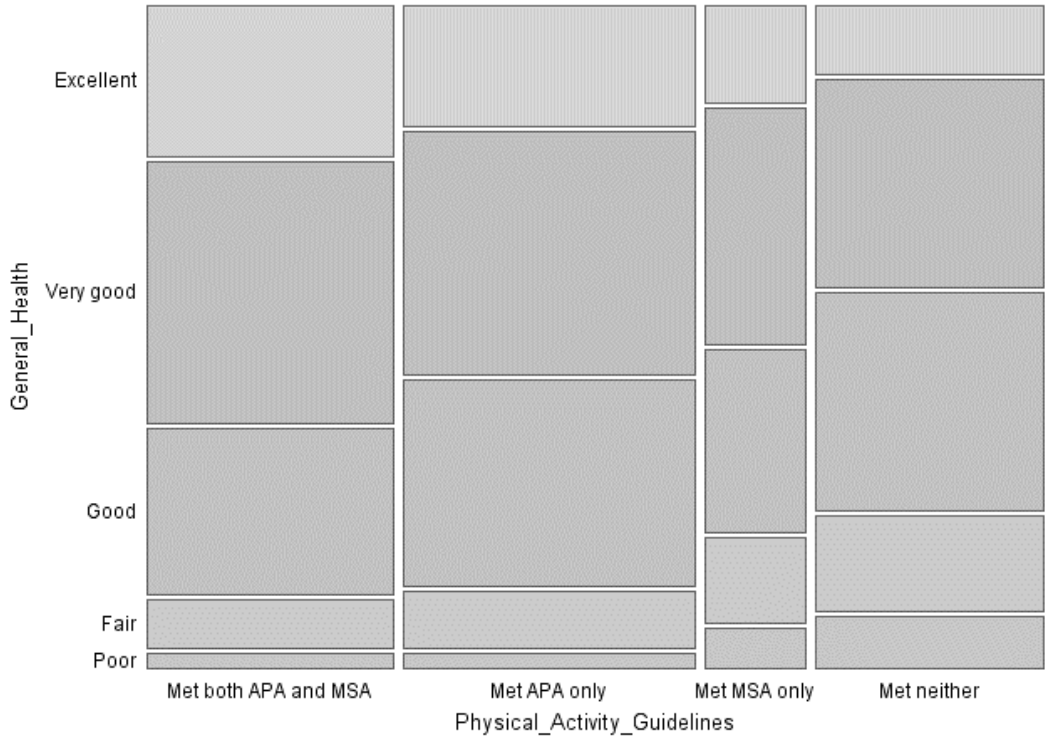

Figure 2. Mosaic plot displaying the distribution of general health by PA guidelines in Montana adults, 2019 (Note. N = 5,810. χ^2_{RS} = 172.8, p < .0001)

Figure 1 is a mosaic plot displaying the distribution of general health by BMI categories in Montana adults. Visually, the plot indicates that general health status is dependent on BMI category. This visual pattern is consistent with the significant chi-square test, χ^2_{RS} = 395.3, p < .0001. Figure 2 is a different mosaic plot displaying the distribution of general health by PA guideline status. Similarly, the plot indicates that general health status is dependent on PA guideline status. This visual pattern is consistent with the significant chi-square test, χ^2_{RS} = 172.8, p < .0001.

4. Discussion

The purpose of this study was to examine how meeting PA guidelines and BMI affect a measure of HRQOL in adults. Results indicate that meeting PA guidelines and

BMI independently predict different levels of HRQOL in adults. Specifically, meeting APA was associated with decreased odds of reporting all lower general health categories, relative to excellent health, controlling for BMI and sociodemographic variables. Similar results were seen for the meeting both APA/MSA analyses. The noteworthy finding was that the MSA predictor was not robustly related to HRQOL. In fact, meeting MSA decreased the odds of reporting only good health, relative to excellent health, controlling for BMI and sociodemographic variables. In other words, MSA could not predict varying levels of reported general health. This finding may also suggest that the PA and HRQOL relationship seen in the APA/MSA analyses was due primarily to the APA effect on HRQOL and not MSA. Another interesting discussion point from this study is the fact that BMI was significantly related to HRQOL in all analyses. Specifically, odds of reporting all lower general health categories increased, relative to excellent health, as BMI increased – and did so consistently in APA, MSA, and APA/MSA models, independent of PA and all sociodemographic variables.

There are some limitations worth mentioning about these findings. One such limitation is the cross-sectional nature of the BRFSS. Cross-sectional research is limited to correlational generalizations and not cause-and-effect inferences that can be identified using experimental designs. Regardless of this limitation, the findings of this study are consistent with those of other studies. For example, a large study of over 1,900 participants found that adults meeting 150+ minutes of accelerometer-determined moderate-to-vigorous PA per week had significantly greater HRQOL scores than counterparts not meeting the same PA guideline [22]. Another limitation of this study is that the data were collected via telephone. This becomes a limitation if certain segments of the population are less likely to have access to a phone. Moreover, these subpopulations may be less likely to meet PA guidelines, more likely to report poor health status, and more likely to be obese. A final limitation of this study is the use of self-reported assessments of PA, BMI, and HRQOL. Given these limitations, findings from this study should be interpreted with caution.

5. Conclusions

This study found that meeting PA guidelines and BMI were both independently related to HRQOL in adults. However, meeting MSA showed lower effects and inconsistent effects on HRQOL. Health promotion specialists concerned with improving HRQOL should promote both APA and MSA guidelines along with healthy body weight status. Physical activity programming should consider APA a priority over MSA for improving HRQOL in Montana adults.

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