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Association of Joint Body Weight Profile and Physical Activity with Cardiovascular Disease Risk in Montana Adults

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Abstract **Background**: There is much debate surrounding the *fat but fit* paradox, namely, questioning the extent to which physical fitness protects obese/overweight populations from premature mortality. The purpose of this study was to examine the link between joint body weight (BW) profile and physical activity (PA) (BW.PA) and cardiovascular disease (CVD) risk in adults. **Methods**: Data for this study came from the 2019 Montana Behavioral Risk Factor Surveillance System (BRFSS). Participants were firstly assigned to one of three BW groups (normal weight, overweight, obese) using CDC BMI criteria, secondly assigned to one of three PA groups (active, insufficiently active, inactive) using self-reported moderate-to-vigorous PA (MVPA), and finally assigned to one of the resulting nine joint BW.PA groups. Three main CVD risk factors (hypertension, hypercholesterolemia, diabetes) were used as separate and then combined outcomes. Logistic regression was employed to estimate the odds of having a CVD risk factor for each BW.PA group, relative to "normal weight and active". **Results**: A direct linear trend in odds ratios (ORs) was observed across BW.PA groups for each CVD risk factor, from "normal weight and active" to "obese and inactive". Fully adjusted regression models showed increased odds of having any of the three CVD risk factors (versus having none) for adults "overweight and active" (OR = 2.22, 95% CI: 1.73 – 2.85) and adults "obese and active" (OR = 4.03, 95% CI: 3.08 – 5.27), compared to those "normal weight and active". Odds were also significantly ($p < .05$) greater for the "obese and active" as compared to the "overweight and active". Additionally, PA did not significantly alter odds of having any CVD risk factor in obese populations. **Conclusion**: This study found that BW profile was a strong and consistent predictor of three primary CVD risk factors. Obese adults were much more likely to have CVD risk, regardless of PA participation. Hence, *fat but fit* may not be a paradox among adults in Montana.

Keywords: *Physical activity (PA), overweight, obesity, cardiovascular disease*

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1. Introduction

The *obesity paradox* is a phenomenon where among those afflicted with certain diseases, those who are overweight or obese have better rates of survival as compared to those with healthier weight classification [1]. The *fat but fit* phenomenon has been put forward as one possible explanation for the obesity paradox and proposes that a subgroup of heavier individuals may possess the protective effects of greater cardiorespiratory fitness [2]. In particular, it is suggested that physical fitness plays a role in cardiovascular disease (CVD) risk, however, this relationship may not be consistent across all body weight profiles [3,4]. One recent study attempted to clarify the joint relationship of body mass index (BMI) and physical activity (PA) on CVD risk and found that PA had little CVD risk protection among the obese population [5]. However, this study 1) included only health insured participants, 2) neglected to formally test for trends in the data, and 3) did not make direct comparisons between joint BMI and PA groups. Hence, the current study addresses these aforementioned limitations and uses a broad state-based sample of adults. The specific aim of this study was to examine the link between joint body weight (BW) profile and physical activity (PA) (BW.PA) and cardiovascular disease (CVD) risk in a representative sample of adults from Montana.

2. Materials & Methods

Data for this study came from the 2019 Behavioral Risk Factor Surveillance System (BRFSS). Details regarding the BRFSS methodology can be found elsewhere [6,7]. The BRFSS is a state-based annual telephone survey designed to collect data on health-risk behaviors in

noninstitutionalized United States (U.S.) adults 18+ years of age. For this study, Montana data were separated from the national dataset.

Nine different BW and PA groups were created to form the joint BW.PA variable. Firstly, participants were assigned to one of three BW groups using CDC BMI criteria of "normal weight" (18.5 kg/m^2 <= BMI < 25.0 kg/m^2), "overweight" (25.0 kg/m^2 <= BMI < 30.0 kg/m^2), and "obese" (BMI >= 30.0 kg/m^2) [8]. Secondly, participants were assigned to one of three PA groups using self-reported moderate-to-vigorous PA (MVPA), consisting of "active" (reporting 150+ minutes of moderate (or vigorous equivalent) PA per week), "insufficiently active" (reporting being physically active but less than 150 minutes per week), and "inactive" (reporting no PA) [9,10]. Finally, participants were assigned to one of the resulting nine joint BW.PA groups ranging from "normal weight and active" to "obese and inactive".

Three main CVD risk factors were used as separate outcome variables. First, a binary "hypertension" variable was created where participants were considered having hypertension if they reported ever being told by a health professional that they have high blood pressure (or reported taking blood pressure medication). Second, a binary "hypercholesterolemia" variable was created where participants were considered having hypercholesterolemia if they reported ever being told by a health professional that they have high blood cholesterol (or reported taking cholesterol medication). Third, a binary "diabetes" variable was created where participants were considered having diabetes if they reported ever being told that they have diabetes. A fourth binary outcome variable was created and indicated that a participant has either a CVD risk factor or no risk factors. Study covariates included smoking, alcohol consumption, sex, age, race, income, education, and marital status.

Logistic regression was used to estimate the odds of having a CVD risk factor (versus not) for each joint BW.PA group, relative to the "normal weight and active" group. The Cochran-Armitage trend test was used to examine the linear trend of odds ratios (ORs) across joint BW.PA groups for each CVD risk factor. Additionally, multiple comparisons were made between pairs of BW.PA groups. Analyses were weighted to produce generalizations representative of noninstitutionalized adults in Montana. SAS version 9.4 was used for all analyses [11].

3. Results

A total of N = 5,479 and N = 4,766 participants had complete data for the unadjusted and adjusted analyses, respectively. Table 1 contains the distribution of CVD risk factor status by joint BW.PA groups. These results show a clear direct linear relationship between CVD risk prevalence and joint BW.PA categories, with risk factor prevalence directly proportional to (excluding the "normal weight and insufficiently active") BW.PA risk groups (Z = 220.8, p < .0001). Figure 1 displays unadjusted ORs with 95% confidence intervals (CIs) for each CVD risk variable across joint BW.PA groups. Similarly, a clear linear trend is observed for each figure (ps < .0001). Table 2 contains results from the fully adjusted multiple logistic regression analyses examining the association between joint BW.PA and CVD risk. Results show a trend toward a greater CVD risk odds (OR range: 1.61 to 3.67) for overweight populations (compared to normal weight) and an even greater CVD risk odds (OR range: 2.41 to 9.86) for obese populations (compared to normal weight). The adjusted ORs also displayed significant (ps < .0001) linear trend across BW.PA groups for each CVD risk factor outcome. With just one exception (inactive in diabetes model), PA did not differentiate odds of CVD risk in normal weight populations. Similarly, with few exceptions, PA did not differentiate odds of CVD risk in overweight populations. Furthermore, PA did not differentiate any CVD risk odds among obese populations. For all CVD risk factor outcomes, across all PA levels, obese populations had significantly greater odds of CVD risk in comparison to overweight and active populations. Finally, sex-by-BW.PA interactions were not significant (ps > .05) in any CVD risk model. Thus, sex differences for these findings are not generalizable.

Table 1. Distribution of cardiovascular disease (CVD) risk factor status by joint body weight profile (BW) and physical activity (PA) (BW.PA) in Montana adults, 2019

	Any CVD Risk Factor							
	Yes				No			
Body Weight/Physical Activity (BW.PA)	*%*	*SE*	*LL*	*UL*	*%*	*SE*	*LL*	*UL*
Normal Weight/Active	25.6	1.4	22.9	28.2	74.4	1.4	71.8	77.1
Normal Weight/Insufficiently Active	17.9	2.7	12.7	23.1	82.1	2.7	76.9	87.3
Normal Weight/Inactive	32.8	3.1	26.8	38.9	67.2	3.1	61.1	73.2
Overweight/Active	42.6	1.6	39.5	45.8	57.4	1.6	54.2	60.5
Overweight/Insufficiently Active	44.7	3.4	38.0	51.4	55.3	3.4	48.6	62.0
Overweight/Inactive	48.6	3.0	42.8	54.5	51.4	3.0	45.5	57.2
Obese/Active	55.0	2.0	51.0	59.0	45.0	2.0	41.0	49.0
Obese/Insufficiently Active	55.6	3.7	48.3	62.9	44.4	3.7	37.1	51.7
Obese/Inactive	64.1	2.8	58.7	69.5	35.9	2.8	30.5	41.3

Note. N = 5,479. % is weighted percentage. SE is standard error. LL and UL are the lower limit and upper limit for the 95% confidence interval estimating population percentage. The Cochran-Armitage trend test using the weighted sample was significant (p < .0001).

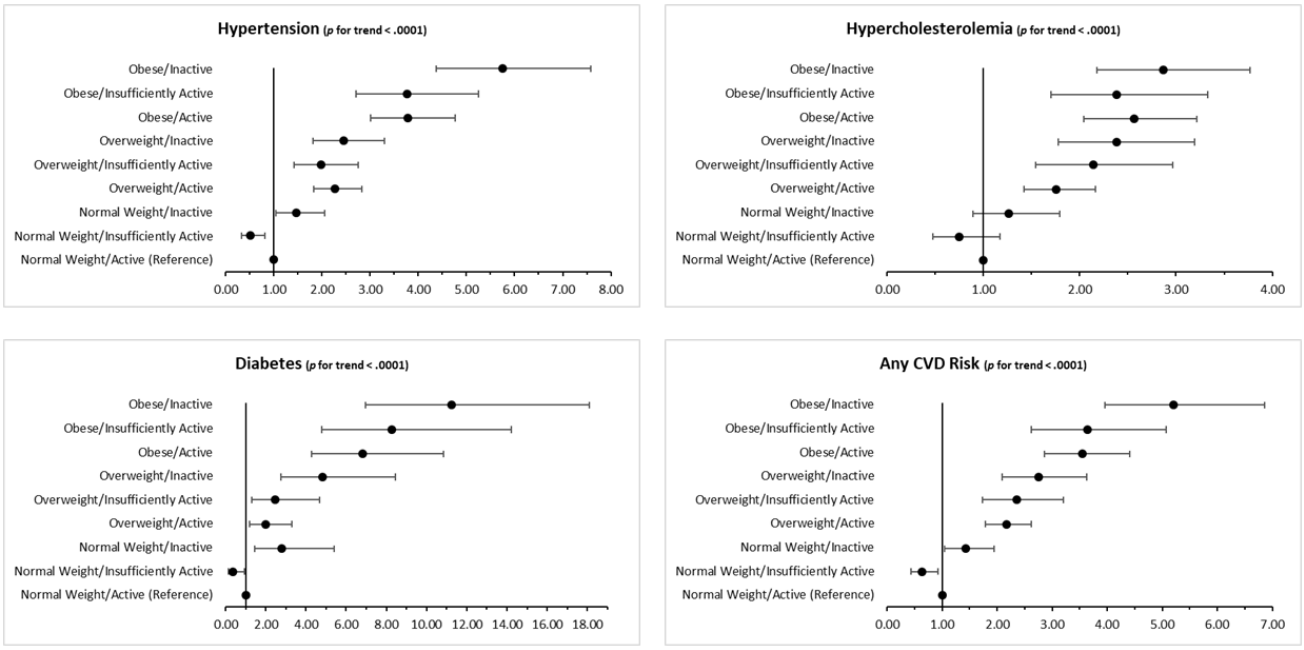

Figure 1. Odds ratios (ORs) (dots) with 95% confidence intervals (CIs) (horizontal bars) for each cardiovascular disease (CVD) risk factor relative to joint body weight profile (BW) and physical activity (PA) (BW.PA). *N* = 5,479. ORs are unadjusted. Cochran-Armitage trend test is significant (*p*s < .0001) for all CVD risk factors

Table 2. Multiple regression analyses examining the association between joint body weight profile (BW) and physical activity (PA) (BW.PA) and cardiovascular disease (CVD) risk factors in Montana adults, 2019

	Hypertension			Hypercholesterolemia			Diabetes			Any CVD Risk Factor		
Body Weight/Physical Activity (BW.PA)	*OR*	*LL*	*UL*	*OR*	*LL*	*UL*	*OR*	*LL*	*UL*	*OR*	*LL*	*UL*
Normal Weight/Active (Reference)	1.00	reference		1.00	reference		1.00	reference		1.00	reference	
Normal Weight/Insufficiently Active	0.92	0.56	1.53	1.59	0.95	2.65	0.62	0.20	1.88	1.32	0.84	2.08
Normal Weight/Inactive	0.99	0.66	1.49	1.10	0.71	1.69	**2.47**	1.18	5.19	1.12	0.75	1.66
Overweight/Active	**2.16**	1.65	2.83	**1.73**^{d}	1.36	2.19	**2.07**^{e}	1.19	3.62	**2.22**^{d}	1.73	2.85
Overweight/Insufficiently Active	**2.53**	1.72	3.74	**2.84**	1.95	4.14	**3.17**	1.49	6.75	**3.67**^{e}	2.57	5.24
Overweight/Inactive	**1.61**^{d}	1.15	2.27	**1.88**	1.32	2.67	**3.60**	1.86	6.97	**2.11**	1.50	2.97
Obese/Active	**4.02**^{a,b,c}	3.04	5.30	**2.63**^{a}	2.02	3.43	**7.15**^{a,b,c}	4.18	12.25	**4.03**^{a,c}	3.08	5.27
Obese/Insufficiently Active	**4.76**^{a,b,c}	3.22	7.03	**2.92**^{a}	1.98	4.31	**9.92**^{a,b,c}	5.31	18.53	**4.92**^{a,c}	3.30	7.33
Obese/Inactive	**4.80**^{a,b,c}	3.49	6.61	**2.41**^{a}	1.75	3.30	**9.86**^{a,b,c}	5.69	17.07	**4.72**^{a,c}	3.43	6.50
p for trend	< .0001			< .0001			< .0001			< .0001		

Note. *N* = 4,766 for all models. OR is odds ratio. LL and UL are the lower limit and upper limit for the 95% confidence interval estimating population OR. Models adjusted for age, sex, race/ethnicity, income, education, marital status, smoking status, and alcohol consumption. ORs in bold are significantly ($p < .05$) different from reference group. *a* superscript indicates OR is significantly ($p < .05$) different from "Overweight/Active" group. *b* superscript indicates OR is significantly ($p < .05$) different from "Overweight/Insufficiently Active" group. *c* superscript indicates OR is significantly ($p < .05$) different from "Overweight/Inactive group". *d* superscript indicates OR is significantly ($p < .05$) different from "Overweight/Insufficiently Active" group. *e* superscript indicates OR is significantly ($p < .05$) different from "Overweight/Inactive" group. Cochran-Armitage trend test is significant (*p*s < .0001) for all CVD risk factors. The sex-by-BW.PA interaction was not significant (*p*s > .05) in any CVD risk model.

5. Discussion

There are a few noteworthy findings from this study worth discussing. For one, with joint BW.PA groups arranged in ranked order of first BW (normal weight, overweight, obese) and second PA (active, insufficiently active, inactive), a clear linear trend was observed in prevalence of CVD risk, for all risk factor outcomes. This trend, on the surface, highlights the fact that both BW and PA relate to CVD risk. For two, closer inspection of this relationship shows that PA had no effect on the BW and CVD risk relationship among those with normal weight (exception for diabetes) and among those obese. PA did alter the BW and CVD risk relationship among the overweight, but in different ways depending on the CVD risk factor. Specifically, the "overweight and active" population saw lower odds of diabetes only, compared to their inactive counterparts. Albeit, the "overweight and active" population still had twice the odds of diabetes, as compared to their "normal weight and active" counterparts.

A large prospective study of adults from Norway found similar results where risk of diabetes increased dramatically across BMI groups (normal, overweight, obese) but only changed modestly due to PA within each BMI group [12]. A large study of adults from Australia,

however, found results countering these where the association between BMI groups (normal, overweight, obese) and diabetes was not significantly changed across PA tertiles [13]. These findings combined suggest that the *fat but fit* phenomenon is likely nonexistent among obese adults in Montana. The phenomenon is, however, likely present in overweight populations for the CVD risk of diabetes, with PA only inhibiting its risk.

Strengths regarding this study are its use of a current and representative sample of noninstitutionalized adults in Montana and its battery of survey questions assessing various CVD risk factors. Limitations include the cross-sectional nature of data and the fact that all variables were assessed via self-report interviews. Therefore, participant misclassification cannot be ruled out due to item and reporting bias. Thus, findings from this study should be considered with caution.

4. Conclusions

This study found that joint BW and PA has a linear relationship with CVD risk, when examined crudely. BW appears to account for a much larger increase in CVD risk than PA. Furthermore, PA had no impact on CVD risk among obese populations and moderate impact on CVD risk concerning diabetes. These results suggest that the *fat but fit* phenomenon is not a true paradox among obese adults in Montana. The phenomenon is likely modestly present in overweight populations for the CVD risk of diabetes only.

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