

The manuscript conducted a systematic review of anthropometric measure and body compositions in people with chronic spinal cord injury. The review revealed inaccuracy of a traditional measure, body mass index, to assess the body compositions in this specific population compared to other measures such as adiposity and lean mass. The study was conducted with a standardized method of reviewing studies that are thorough and appropriate for this review. There is no major concern but requiring minor changes that are raised in the comments.

Response: We are immensely grateful for your consideration and careful look at our manuscript. We have followed most of your suggestions and responded to your comments/queries below. You are accurate in pointing out the main issues raised by our manuscript. We hope that the pooled effect estimate (weighted mean difference) would be an excellent contribution to the growing literature on obesity in individuals with SCI.

Recommendations:

The authors described the importance of screening methods to identify a risk of cardiovascular diseases based on some indices such as anthropometric measures. However, the authors did not introduce how impactful body indices, that can differentiate populations with high risks of cardiovascular condition from people with spinal cord injury, can improve their quality of life and social participation. In order to show the issues, the authors can add a more detailed prevalence of cardiovascular conditions for their QOL and mortality to the introduction in the first paragraph. In addition to body compositions such as fat, there are other causes of cardiovascular diseases like autonomic dysreflexia or medications. Therefore, the authors can explain more about associated factors that were not investigated in this systematic review in the introduction and the knowledge gaps and future research section.

DONE. We agree with the reviewer. One of the most neglected topics is the sex disparity on most clinical outcomes for SCI, which also holds for cardiovascular diseases.

Line 465-469:

Lastly, more female-specific studies on body composition are also needed. The current literature predominantly comes from males, albeit sex is a significant determinant for adiposity in the general population. There are established hormonal changes across different reproductive stages that influence adiposity in females, and as such, this field has yet to be explored.

It was not clear why high vs. low paraplegia showed no difference of anthropometric measures although paraplegia and tetraplegia showed differences. The authors can add the observations and discussion about that regardless of more impaired autonomic function in high paraplegia compared to low paraplegia, there was no difference to the section 4.1 discussion.

DONE. We added a paragraph to highlight this finding and offer a plausible explanation.

Line 341-346:

We did not observe differences in body composition between high and low para-plegia. We surmise that the two groups may have similar levels of physical activity and function. The two groups may also have similar dietary patterns precluding any changes in energy balance. High paraplegia has more autonomic impairment compared to low paraplegia. However, it may be insufficient to cause significant differences in body composition.

Lastly, although the authors emphasized the importance of taking duration since injury as an associated factor, there was no result shown beside the association between duration vs. weight and a source of heterogeneity for weight circumference. In the result section, the authors can add non-significant findings of duration of the injury. Furthermore, the authors can add more discussion why duration since injury is still an important factor for body composition and health risks in this population to the discussion section.

DONE: We agree that other injury characteristics (i.e., injury duration and completeness) are important factors in body composition in SCI. Thus, we included this as part of the heterogeneity analysis. Indeed, these were shown as sources of heterogeneity in our analysis. In this revision, we have added more details in the heterogeneity analysis results (injury completeness and duration) and explained the results in the discussion,

Line 283-298: (Results)

3.5. Heterogeneity and subgroup analyses

We identified substantial heterogeneity ($I^2 > 50-90\%$) on seven outcomes (38.8%) among 18 outcomes-of-interest (Table 2). In subgroup analyses and meta-regression: (i) sex was identified as a source of heterogeneity for BMI and weight; (ii) the proportion of complete injury was a source of heterogeneity for body weight, and (iii) age and duration of injury was a source of heterogeneity for waist circumference (Table S4). Results of restriction analysis using body composition as primary outcome can be found in the Online Appendix (Figure S1).

Restricting the analysis to studies with only complete injuries, weight is higher in paraplegia compared to tetraplegia (WMD -1.7 kg, 95% CI -2.5, -0.9), while those with mixed (complete and incomplete) showed no statistical difference (Table S4). Thus, injury completeness was determined as a source of heterogeneity. For those with longer duration of injury (above the median injury duration), individuals with tetraplegia have higher waist circumference and weight but did not reach statistical significance. The trend was opposite compared to those with shorter duration of injury (i.e., tetraplegia has lower waist circumference and weight compared to paraplegia).

Line 349-361: (Discussion)

We showed injury completeness and duration were sources of heterogeneity in our meta-analysis. Complete injury has low to absent residual motor or sensory function below the injury level. As such, complete injury has lower resting energy requirement (82), and higher fat composition than incomplete injury (16, 43). In our analysis, studies have different proportions of complete injury that caused high heterogeneity in our analysis. Aging is a strong risk factor for fat composition and obesity owing to the physiologic changes associated with senescence. However, injury duration and aging are two variables that are difficult to disentangle as they are closely associated with each other. Studies have shown that longer duration of injury and the older individuals have higher fat composition (16, 43). According to the injury level, we did not see any statistically significant finding in waist circumference and weight. But when stratifying by injury duration, higher waist circumference and weight were seen in tetra-plegia compared to paraplegia for those with longer injury duration.

Minor suggestions:

There are several citation and period inconsistencies like “mentioned(26).” Page 3 145-146, Page 11 line 373-375, line 386.

DONE. We have revised this in this current version. Changes can be found in the whole manuscript.

1. Page 3 140-142 define completeness of injury, motor or sensory?

DONE. Completeness of injury was defined differently in many studies. As such, for this review, we defined this as motor-sensory complete (AIS A) or motor complete (AIS A and B), or plain complete and incomplete depending on the classification used in individual studies. This can be found in the footnote of Table 1.

Table 1. Characteristics of studies included in the meta-analysis

Characteristics	No. of studies	References
Level of injury ¹		
Tetraplegia vs paraplegia	36	Akbal 2013 (28), Azevedo 2016 (29), Bauman 1999 (31), Bauman 1999 (30), Buchholz 2009 (32), de Groot 2008 (34), Chun 2017 (33), Farkas 2019 (37), Flueck 2020 (36), Gater 2021 (38), Gibson 2008 (74), Gomes Costa 2019 (75), Gorgey 2011A (10), Han 2015 (40), Janssen 1997 (42), Katzelnick 2019 (44), Kemp 2000 (45), Kim 2016 (46), Li 2019 (11), Matos Souza 2010 (48), McCaulay 2018 (49), Miyatani 2014 (50), O'Brien 2017 (51), Pelletier 2016 (12), Powell 2017 (52), Rankin 2017 (53), Raymond 2010 (54), Ribeiro Neto 2013 (55), Sabour 2013 (56), Spungen 2003 (13), Sumrell 2018 (57), Wang 2005 (59), Wang 2007 (58), Yahiyo 2019 (60), Yilmaz 2007 (61), Zhu 2013 (62)
High paraplegia vs. low paraplegia	12	Dionyssiotsis 2008 (35), Gomes Costa 2019 (75), Inukai 2006(41), Janssen 1997 (42), Katzelnick 2017 (43), Katzelnick 2019 (44), Kim 2016 (46), Lee 2017 (47), Raymond 2010 (54), Ribeiro Neto 2013 (55), Wang 2007 (58), Zhu 2013 (62)
Proportion of complete injury ²		
100%	12	Bauman 1999 (30), Chun 2017 (33), Dionyssiotsis 2008 (35), Farkas 2019 (37), Gater 2021 (38), Gomes Costa 2019 (75), Gorgey 2011A (10), Rankin 2017 (53), Sumrell 2018 (57), Wang 2005 (59), Wang 2007 (58), Yilmaz 2007 (61)
Mixed	15	Akbal 2013 (28), Azevedo 2016 (29), de Groot 2008 (34), Gibson 2008 (74), Janssen 1997 (42), Katzelnick 2017 (43), Katzelnick 2019 (44), Kemp 2000 (45), O'Brien 2017 (51), Pelletier 2016 (12), Powell 2017 (52), Raymond 2010 (54), Ribeiro Neto 2013 (55), Sabour 2013 (56), Spungen 2003 (13)
Duration of injury (years) ³		
≤ 12.3 y (IQR 8.03-14.8)	19	Akbal 2013 (28), Azevedo 2016 (29), Bauman 1999 (30), Chun 2017 (33), Dionyssiotsis 2008 (35), Gomes Costa 2019 (75), Han 2015 (40), Katzelnick 2017 (43), Lee 2017 (47), Matos Souza 2010 (48), McCaulay 2018 (49), O'Brien 2017 (51), Rankin 2017 (53), Raymond 2010 (54), Ribeiro Neto 2013 (55), Sabour 2013 (56), Sumrell 2018 (57), Wang 2005 (59), Wang 2007 (58), Yilmaz 2007 (61)
>12.3 y	18	Bauman 1999 (31), Buchholz 2009 (32), de Groot 2008 (34), Farkas 2019 (37), Flueck 2020 (36), Gater 2021 (38), Gibson 2008 (74), Inukai 2006 (41), Janssen 1997 (42), Katzelnick 2019 (44), Kemp 2000 (45), Li 2019 (11), Miyatani 2014 (50), Pelletier 2016 (12), Spungen 2003 (13), Yahiyo 2019 (60), Zhu 2013 (62)
Sex		
Males only	19	Azevedo 2016 (29), Bauman 1999 (31), Bauman 1999 (30), Dionyssiotsis 2008 (35), Gomes Costa 2019 (75), Gorgey 2011A (10), Inukai 2006 (41), Janssen 1997 (42), Matos Souza 2010 (48), McCaulay 2018 (49), O'Brien 2017 (51), Rankin 2017 (53),

		Ribeiro Neto 2013 (55), Spungen 2003 (13), Sumrell 2018 (57), Wang 2005 (59), Wang 2007 (58), Yahiro 2019 (60), Yilmaz 2007 (61)
Both	19	Buchholz 2009 (32), de Groot 2008 (34), Chun 2017 (33), Farkas 2019 (37), Flueck 2020 (36), Gater 2021 (38), Gibson 2008, Han 2015 (40), Katzelnick 2017 (43), Katzelnick 2019 (44), Kemp 2000 (45), Kim 2016 (46), Lee 2017 (47), Miyatani 2014 (50), Pelletier 2016 (12), Powell 2017 (52), Raymond 2010 (54), Sabour 2013 (56), Zhu 2013 (62)
Female only	1	Li 2019 (11)
Unknown	1	Akbal 2013 (28)
Study size		
<50	18	Azevedo 2016 (29), Dionyssiotis 2008 (35), Farkas 2019 (37), Gomes Costa 2019 (75), Gorgey 2011A (10), Inukai 2006 (41), Janssen 1997 (42), Katzelnick 2019 (44), Kim 2016 (46), Lee 2017 (47), Li 2019 (11), Matos Souza 2010 (48), McCaulay 2018 (49), O'Brien 2017 (51), Rankin 2017 (53), Raymond 2010 (54), Sumrell 2018 (57), Yilmaz 2007 (61)
50-100	9	Akbal 2013 (28), Buchholz 2009 (32), Chun 2017 (33), Flueck 2020 (36), Gater 2021 (38), Gibson 2008 (74), Miyatani 2014 (50), Ribeiro Neto 2013 (55), Wang 2007 (58)
>100	13	Bauman 1992 (31), Bauman 1999 (30), de Groot 2008 (34), Han 2015 (40), Katzelnick 2019 (44), Kemp 2000 (45), Pelletier 2016 (12), Powell 2017 (52), Sabour 2013 (56), Spungen 2003 (13), Wang 2005 (59), Yahiro 2019 (60), Zhu 2013 (62)
Age, years		
≤39.1 y (IQR 36–42.4)	20	Akbal 2013 (28), Azevedo 2016 (29), Bauman 1999 (30), Flueck 2020 (36), Gomes Costa 2019 (75), Gorgey 2011A (10), Inukai 2006 (41), Janssen 1997 (42), Katzelnick 2017 (43), Lee 2017 (47), Matos Souza 2010 (48), McCaulay 2018 (49), O'Brien 2017 (51), Rankin 2017 (53), Raymond 2010 (54), Ribeiro Neto 2013 (55), Sabour 2013 (56), Spungen 2003 (13), Sumrell 2018 (57), Yilmaz 2007 (61)
>39.1 y	20	Bauman 1992 (31), Buchholz 2009 (32), Chun 2017 (33), de Groot 2008 (34), Dionyssiotis 2008 (35), Farkas 2019 (37), Gater 2021 (38), Gibson 2008 (74), Han 2015 (40), Katzelnick 2019 (44), Kemp 2000 (45), Kim 2016 (46), Li 2019 (11), Miyatani 2014 (50), Pelletier 2016 (12), Powell 2017 (52), Wang 2005 (59), Wang 2007 (58), Yahiro 2019 (60), Zhu 2013 (62)
Location		
Europe	4	de Groot 2008 (34), Dionyssiotis 2008 (35), Flueck 2020 (36), Janssen 1997 (42)
North America	23	Azevedo 2016 (29), Bauman 1992 (31), Bauman 1999 (30), Buchholz 2009 (32), Farkas 2019 (37), Gater 2021 (38), Gibson 2008 (74), Gorgey 2011A (10), Katzelnick 2017 (43), Katzelnick 2019 (44), Kemp 2000 (45), Kim 2016 (46), Li 2019 (11), McCaulay 2018 (49), Miyatani 2014 (50), O'Brien 2017 (51), Pelletier 2016 (12), Powell 2017 (52), Rankin 2017 (53), Spungen 2003 (13), Sumrell 2018 (57), Yahiro 2019 (60), Zhu 2013 (62)
South America	3	Gomes Costa 2019 (75), Matos Souza 2010 (48), Ribeiro Neto 2013 (55)
Asia	10	Akbal 2013 (28), Chun 2017 (33), Han 2015 (40), Inukai 2006 (41), Lee 2017 (47), Raymond 2010 (54), Sabour 2013 (56), Wang 2005 (59), Wang 2007 (58), Yilmaz 2007 (61)
Outcomes		
Anthropometric measures		
Body mass index (kg/m ²) ^a	35	Akbal 2013 (28), Azevedo 2016 (29), Bauman 1992 (31), Bauman 1999 (30), Buchholz 2009 (32), de Groot 2008 (34), Dionyssiotis 2008 (35), Farkas 2019 (37), Gater 2021 (38), Gibson 2008 (74), Gomes Costa 2019 (75), Gorgey 2011A (10), Han 2015 (40), Janssen 1997 (42), Katzelnick 2017 (43), Katzelnick 2019 (44), Kemp 2000 (45), Kim 2016 (46), Lee 2017 (47), Li 2019 (11), Matos Souza 2010 (48), McCaulay 2018 (49), Miyatani 2014 (50), O'Brien 2017 (51), Pelletier 2016 (12), Powell 2017 (52), Raymond 2010 (54), Ribeiro Neto 2013 (55), Sabour 2013 (56), Spungen 2003 (13), Sumrell 2018 (57), Wang 2005 (59), Wang 2007 (58), Yahiro 2019 (60), Zhu 2013 (62)
Body weight	22	Azevedo 2016 (29), Bauman 1999 (30), Dionyssiotis 2008 (35), Farkas 2019 (37), Flueck 2020 (36), Gibson 2008 (74), Gomes Costa 2019 (75), Janssen 1997 (42), Katzelnick 2017 (43), Kim 2016 (46), Li 2019 (11), McCaulay 2018 (49), Miyatani 2014 (50), O'Brien 2017 (51), Pelletier 2016 (12), Raymond 2010 (54), Ribeiro Neto 2013 (55), Sumrell 2018 (57), Spungen 2003 (13), Wang 2005 (59), Wang 2007 (58), Yahiro 2019 (60)
Waist circumference (cm)	11	Akbal 2013 (28), Buchholz 2009 (32), Gater 2021 (38), Gibson 2008 (74), Inukai 2006 (41) (only in paraplegia), McCaulay 2018 (49), Miyatani 2014 (50), Pelletier 2016 (12), Sabour 2013 (56), Sumrell 2018 (57), Yahiro 2019 (60)
Total body composition		
Body fat percentage (%) ^e	12	Buchholz 2009 (32), Chun 2017 (33), Farkas 2019 (37), Flueck 2020 (36), Gibson 2008, Gorgey 2011A (10), Han 2015 (40), Inukai 2006 (41) (only in paraplegia), Kemp 2000 (45), Li 2019 (11), Pelletier 2016 (12), Spungen 2003 (13)
Body lean mass (kg)	10	Azevedo 2016 (29), Chun 2017 (33), Farkas 2019 (37), Flueck 2020 (36), Gorgey 2011A (10), Li 2019 (11), Pelletier 2016 (12), Ribeiro Neto 2013 (55), Spungen 2003 (13), Yilmaz 2007 (61)
Body fat mass (kg)	6	Azevedo 2016 (29), Farkas 2019 (37), Gorgey 2011A (10), Li 2019 (11), Pelletier 2016 (12), Spungen 2003 (13)
Regional body composition		
Trunk fat percent (%)	5	Farkas 2019 (37), Flueck 2020 (36), Gorgey 2011A (10), Pelletier 2016 (12), Spungen 2003 (13)
Trunk fat mass (kg)	4	Flueck 2020 (36), Gorgey 2011A (10), Pelletier 2016 (12), Spungen 2003 (13)
Trunk lean mass	3	Flueck 2020 (36), Li 2019 (11), Spungen 2003 (13)
Leg fat percent (%)	3	Flueck 2020 (36), Gorgey 2011A (10), Spungen 2003 (13)
Leg fat mass (kg)	2	Gorgey 2011A (10), Spungen 2003 (13)
Visceral adiposity		
Visceral adipose tissue (dm ²)	5	Gorgey 2011 (39), Li 2019 (11), Pelletier 2016 (12), Rankin 2017 (53), Sumrell 2018 (57)
Visceral adipose volume (L)	2	Farkas 2019 (37), Sumrell 2018 (57)
Subcutaneous adipose tissue (dm ²)	2	Gorgey 2011 (39), Rankin 2017 (53)
VAT/SAT ratio	2	Farkas 2019 (37), Sumrell 2018 (57)
Study quality		
Moderate (5-7)	7	Bauman 1992 (31), Flueck 2020 (36), Gomes Costa 2019 (75), Inukai 2006 (41), Rankin 2017 (53), Sumrell 2018 (57), Yilmaz 2007 (61)
Good (8-10)	33	Akbal 2013 (28), Azevedo 2016 (29), Bauman 1999 (30), Buchholz 2009 (32), Chun 2017 (33), de Groot 2008 (34), Dionyssiotis 2008 (35), Farkas 2019 (37), Gater 2021 (38), Gibson 2008 (74), Gorgey 2011A (10), Han 2015 (40), Janssen 1997 (42), Katzelnick 2017 (43), Katzelnick 2019 (44), Kemp 2000 (45), Kim 2016 (46), Lee 2017 (47), Li 2019 (11), Matos Souza 2010 (48), McCaulay 2018 (49), Miyatani 2014 (50), O'Brien 2017 (51), Pelletier 2016 (12), Powell 2017 (52), Raymond 2010 (54), Ribeiro Neto 2013 (55), Sabour 2013 (56), Spungen 2003 (13), Wang 2005 (59), Wang 2007 (58), Yahiro 2019 (60), Zhu 2013 (62)
Cardiovascular diseases and medication-use		

No data	20	Azevedo 2016 (29), Bauman 1992 (31), Bauman 1999 (30), Chun 2017 (33), de Groot 2008 (34), Dionyssiotis 2008 (35), Flueck 2020 (36), Gater 2021 (38), Gibson 2008 (74), Han 2015 (40), Inukai 2006 (41), Katzelnick 2017 (43), Katzelnick 2019 (44), Kemp 2000 (45), Pelletier 2016 (12), Powell 2017 (52), Spungen 2003 (13), Wang 2005 (59), Wang 2007 (58), Yilmaz 2007 (61)
Only healthy subjects (excluded those with cardiovascular disease or medication use)	16	Akbal 2013 (28), Farkas 2019 (37), Gomes Costa 2019 (75), Gorgey 2011A (10), Kim 2016 (46), Lee 2017 (47), Li 2019 (11), Matos Souza 2010 (48), McCaulay 2018 (49), Miyatani 2014 (50), O'Brien 2017 (51), Rankin 2017 (53), Raymond 2010 (54), Ribeiro Neto 2013 (55), Sabour 2013 (56), Sumrell 2018 (57)
Included those with and without cardiovascular comorbidities	4	Buchholz 2009 (32), Janssen 1997 (42), Yahiro 2019 (60), Zhu 2013 (62)
Primary outcome		
Body composition as primary outcome	21	Azevedo 2016 (29), Bauman 1999 (30), Buchholz 2009 (32), Chun 2017 (33), Dionyssiotis 2008 (35), Farkas 2019 (37), Flueck 2020 (36), Gibson 2008 (74), Gorgey 2011A (10), Han 2015 (40), Inukai 2006 (41), Kemp 2000 (45), Li 2019 (11), McCaulay 2018 (49), Pelletier 2016 (12), Rankin 2017 (53), Ribeiro Neto 2013 (55), Sabour 2013 (56), Spungen 2003 (13), Sumrell 2018 (57), Yilmaz 2007 (61),
Body composition as secondary outcome	19	Akbal 2013 (28), Bauman 1992 (31), de Groot 2008 (34), Gater 2021 (38), Gomes Costa 2019 (75), Janssen 1997 (42), Katzelnick 2017 (43), Katzelnick 2019 (44), Kim 2016 (46), Lee 2017 (47), (11), Matos Souza 2010 (48), Miyatani 2014 (50), O'Brien 2017 (51), Powell 2017 (52), Raymond 2010 (54), Wang 2005 (59), Wang 2007 (58), Yahiro 2019 (60), Zhu 2013 (62)

¹Five studies reported injury level as tetraplegia and paraplegia and further into high paraplegia and low paraplegia (44, 46, 55, 58, 62)

²Complete injury either as sensory/motor (AIS A), motor complete (AIS A-B), or clinical labeling of complete. Thirteen studies with no report on injury completeness (11, 31, 32, 36, 40, 41, 46-50, 52, 62)

³Three studies with no duration of injury (10, 46, 52)

⁴Thirty five studies reporting BMI, of which 32 studies comparing tetraplegia and paraplegia, and 12 studies comparing high and low paraplegia.

⁵Twenty two studies reporting weight, of which 20 comparing tetraplegia and paraplegia and 8 studies comparing high and low paraplegia.

⁶Twelve studies reporting body fat percentage, of which 11 comparing tetraplegia and paraplegia and 2 comparing high and low paraplegia.

2. Page 8 237-238 "lean mass was lower in individuals with paraplegia (WMD -2.4 kg 95% CI -5.5, 0.6; I2 84.1%)" must be "tetraplegia". Please correct the description.

DONE. This section was already removed in the current version

The authors would want to add some discussion about ethnicity that may be correlated with the body composition in the 4.3 strength and weaknesses section to consider the significance.

DONE. Although this is an interesting topic, our findings seem insufficient to provide any comment on the impact of ethnicity/race. However, we acknowledge this in the manuscript.

Line 463-464:

Race/ethnicity could also be further investigated as a risk for injury and further as a modifier of the outcome.