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Journal of Sport and Health Science 13 (2024) 13–17

Original article

Older Adult Compendium of Physical Activities: Energy costs of human activities in adults aged 60 and older

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Received 12 September 2023; revised 15 September 2023; accepted 27 September 2023
Available online 17 January 2024

Abstract

Purpose: To describe the development of a Compendium for estimating the energy costs of activities in adults ≥60 years (OA Compendium).
Methods: Physical activities (PAs) and their metabolic equivalent of task (MET) values were obtained from a systematic search of studies published in 4 sport and exercise databases (PubMed, Embase, SPORTDiscus (EBSCOhost), and Scopus) and a review of articles included in the 2011 Adult Compendium that measured PA in older adults. MET values were computed as the oxygen cost (VO_2, mL/kg/min) during PA divided by 2.7 mL/kg/min (MET_{60+}) to account for the lower resting metabolic rate in older adults.
Results: We identified 68 articles and extracted energy expenditure data on 427 PAs. From these, we derived 99 unique Specific Activity codes with corresponding MET_{60+} values for older adults. We developed a website to present the OA Compendium MET_{60+} values: https://pacompendium.com.
Conclusion: The OA Compendium uses data collected from adults ≥60 years for more accurate estimation of the energy cost of PAs in older adults. It is an accessible resource that will allow researchers, educators, and practitioners to find MET_{60+} values for older adults for use in PA research and practice.

Keywords: Energy expenditure; Exercise; MET; Older adults

1. Introduction

The Adult Compendium of Physical Activities (hereafter: Adult Compendium) has a rich history that recognizes the importance of classifying physical activities (PAs) to understand their energy costs. First developed 30 years ago, the Adult Compendium presents a standardized coding system that assigned the metabolic equivalent of tasks (METs) to various PAs to improve consistency across research studies. This system helped to better estimate the effects of PA type and intensity on morbidity, mortality, and health outcomes.[1] The Adult Compendium was updated in 2000[2] and 2011[3] to enhance its comprehensiveness and accuracy. Each revision expanded the number of Specific Activities and refined several MET values.

As the field of PA research continues to evolve, there is a clear need to develop specialized versions of the Adult

Peer review under responsibility of Shanghai University of Sport.
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https://doi.org/10.1016/j.jshs.2023.10.007
Cite this article: Willis EA, Herrmann SD, Hastert M, et al. Older Adult Compendium of Physical Activities: Energy costs of human activities in adults aged 60 and older. *J Sport Health Sci* 2024;13:13–7.

Compendium. In 2018, researchers updated a version of the Youth Compendium from 2008[4] to highlight the differences in the energy costs of PA in children and adolescents (5−18 years).[5] Children have higher resting metabolic rates (RMRs) per unit of body mass than adults, and RMR declines gradually during childhood and adolescence.[6−9] Accordingly, adult MET values do not apply to children or youth, so specific MET values were needed for these populations.[10,11] Beyond childhood, RMR tends to stabilize by age 20 and remains constant until ~60 years.[9] However, starting around age 60, RMR declines by approximately 1% annually.[9] Results from a 2022 systematic review examining measured RMR values in adults ≥60 years found that RMR ranged from 2.4 to 2.7 mL/kg/min, which is 22%−31% lower than the average adult RMR of 3.5 mL/kg/min.[11,12] This decline is due to loss of fat-free mass, impairment of metabolic processes, and health deterioration as individuals age.[13,14] These age-related differences in RMR and the energy costs of PA suggest that adult MET values are not applicable for older adults. Given that by 2050, the proportion of the world population ≥60 years is estimated to almost double from 12% to 22%,[15] there is a need to develop a Compendium for older populations.[16−18]

This paper describes the development of an Older Adult Compendium of Physical Activities (OA Compendium) with MET values based on measured energy costs of PA in adults ≥60 years. The OA Compendium provides a standardized coding system explicitly designed for older adults to support researchers, practitioners, and public health specialists in assigning MET values to PAs in older adults.

2. Methods

PAs and their respective MET values were obtained from a systematic search of articles published in 4 Sport and Exercise databases (PubMed, Embase, SPORTDiscus (EBSCOhost), and Scopus). A detailed description of the search strategy is available from Herrmann et al.[19] Briefly, a systematic search was conducted for articles published since the date of the last Compendium update (January 1, 2011) using a combined search of keywords for the central concept of energy cost (e.g., energy expenditure) combined with search terms for 22 PA Major Headings from the Adult Compendium. In addition, 259 articles referenced in the 2011 Compendium were reviewed to identify those that reported the energy cost of PA in adults ≥60 years. The study team also searched supplementary literature to capture additional articles missed in the systematic search.

2.1. Eligibility criteria

Studies were included if they (a) reported data from participants with a mean age of ≥60 years, (b) assessed the energy cost of PA using indirect calorimetry, (c) reported the energy cost of PA as METs or values that could be converted to METs (e.g., averaged PA oxygen uptake or caloric energy expenditure), and (d) were full-text articles published in English. Articles were excluded if (a) they only reported resting, peak, or maximal energy cost values, (b) participants had a physical disability that altered PA gait or performance (e.g., amputee, spinal cord injury, Parkinson's disease), (c) participants had a chronic disease that limited PA (e.g., chronic obstructive pulmonary disease, coronary heart disease, cancer), or (d) data for converting energy cost values to METs were unavailable (e.g., participant weight and height data or duration of PA were not reported).

2.2. Study selection

Six reviewers (SDH, EAW, TVB, MH, CLK, and JMS) independently screened abstracts for eligibility; 2 reviewers (SDH and EAW) resolved conflicts. Several reviewers (TVB, EAW, MH, and SDH) then screened full-text articles for eligibility criteria. Five reviewers (SDH, EAW, BEA, MH, and CLK) independently extracted participant data (mean age, weight, and height) and energy costs in kcal/min, mL/kg/min, mL/min or in other units of identified PAs. Two reviewers (SDH and EAW) confirmed all data.

2.3. OA Compendium organization and coding scheme

The OA Compendium follows the established organizational structure of the 2024 Adult Compendium to provide consistency in locating Major Headings, codes, Specific Activity descriptions, and MET values (Table 1). We modified the 5-digit coding scheme of the Adult Compendium to derive a 7-digit coding scheme (e.g., 0101260; see Table 1). The first 2 digits represent the Major Heading (i.e., 01 − Bicycling), and the next 3 represent the Specific Activity (i.e., 012 − stationary cycling, 90−100 watts, vigorous effort). The final 2 digits (i.e., 60) are a categorical designation for the OA Compendium (i.e., 60+). In this initial version of the OA Compendium, the final 2 digits include all data reported for adults aged ≥60 years, expressing the value as 60+.

2.4. Intensity of activities

The Adult Compendium presents the energy costs of PAs as standard METs, with 1 MET defined as 1.0 kcal/kg/h and operationalized as 3.5 mL/kg/min (oxygen cost during PA

Table 1
Example of the OA Compendium organizational scheme.

OA Compendium code[a]	MET_{60+}	Major Heading	Specific Activity
0101260	5.3	Bicycling	Bicycling, stationary, 90−100 watts, vigorous effort
0205160	3.0	Conditioning	Resistance (weight) training, squats, light effort
0303060	6.0	Dancing	Ballroom dance (tango, slow waltz, foxtrot)
0510060	4.0	Home activities	Making bed, changing linens

[a] OA Compendium code: The first 2 numbers represent the Major Heading, the third to fifth numbers represent the Specific Activity, and the final 2 numbers, "60" identify the code for the OA Compendium for adults ≥60 years. MET_{60+} identifies the older adult MET value using 2.7 mL/kg/min as the resting metabolic rate. Abbreviations: MET = metabolic equivalent; OA Compendium = Older Adult Compendium of Physical Activities.

in mL/kg/min divided by 3.5 mL/kg/min).[12] However, as researchers have noted that the standard MET definition used in the Adult Compendium underestimates the individual energy costs of PA in older adults,[11] we present PA intensities with standard values specific to older adults (MET_{60+}). Based on the work by Leal-Martin et al.,[11] we used 2.7 mL/kg/min as the denominator for calculating MET_{60+}. For example, a PA with a measured energy cost of 12.5 mL/kg/min is divided by 2.7 mL/kg/min to obtain a MET_{60+} of 4.63, approximately 4.6 times the energy cost of resting.

We applied sample weights to the MET_{60+} values for Specific Activities when multiple studies measured the energy cost of similar PAs. Weights were based on sample sizes to give larger studies with narrower confidence intervals more weight. Weighting methods are described in the Appendix. Weighted MET_{60+} values in the OA Compendium were rounded to the nearest significant digit of 0, 3, 5, and 8 to match the Adult Compendium. For example, a MET_{60+} of 4.63 was rounded to 4.5, and a MET_{60+} value of 3.96 was rounded to 4.0.

3. Results

The literature review yielded 50 articles with energy cost data collected from adults ≥60 years. In addition, 15 articles were identified from the 2011 Compendium with data collected from adults ≥60 years, and 3 articles were identified through supplementary literature searches. We extracted data on 427 measured PAs from 68 articles. These activities fit into 16 of the 22 Major Headings in the Adult Compendium (Table 2). Most were categorized into 4 Major Headings: Walking ($n = 106$), Home activities ($n = 99$), Conditioning exercises ($n = 72$), and Lawn and garden ($n = 55$). Major Headings for Inactivity, Video games, and Bicycling had 22, 21, and 14 Specific Activities, respectively. The remaining 9 Major Headings had 10 or fewer Specific Activities. No data on the energy cost of PAs in older adults were identified in the literature for Major Headings of Fishing and hunting, Music playing, Sexual activity, Water activities, Religious activities, and Volunteer activities. After combining similar activities, 99 unique 7-digit Specific Activity codes were created for the OA Compendium.

All articles ($n = 68$) reported sample data for age (68.2 ± 5.4 years; mean ± SD), 60 reported weight (71.2 ± 7.9 kg), and 52 reported height (165.0 ± 7.5 cm). Most studies were based on participants aged 60−70 years (55.2%), though some reported MET values from samples 70−79 years (41.2%) or 80−89 years (2.9%). No study included samples with an average age >90 years, although some did include measures on people in their nineties.

Table 2
Major Headings and 99 Specific Activities in the Older Adult Compendium of Physical Activities.

Major Heading number – Name (Total number of Specific Activity codes)		
01 – Bicycling (5)	09 – Miscellaneous (1)	17 – Walking (20)
02 – Conditioning exercises (15)	10 – Music playing (0)	18 – Water activities (0)
03 – Dancing (3)	11 – Occupation (1)	19 – Winter activities (3)
04 – Fishing and hunting (0)	12 – Running (2)	20 – Religious activities (0)
05 – Home activities (16)	13 – Self-care (2)	21 – Volunteer activities (0)
06 – Home repair (1)	14 – Sexual activity (0)	22 – Video games (5)
07 – Inactivity (5)	15 – Sports (3)	
08 – Lawn and garden (16)	16 – Transportation (1)	

4. Discussion

The older adult population is growing rapidly,[15] and there is substantial evidence that PA supports healthy aging.[20] However, limited data exist on the energy cost of PA in older adults.[16] We conducted a comprehensive literature review to identify the measured energy cost of PAs in adults ≥60 years to develop a Compendium of Physical Activities for older adults. Overall, we found a scarcity of data, with only 99 unique PAs for older adults, compared with 196 PAs in the 2018 Youth Compendium[5] and over 1000 PAs in the 2024 Adult Compendium.[19] This scarcity reinforces the need for further research on the energy costs of PA in older adults, which will inform PA and health research and support public health guidelines.

Most of the Specific Activities were under 4 of the 22 Major Headings in the Adult Compendium (Walking, Home activities, Conditioning exercises, and Lawn and garden). Activities under these Major Headings (e.g., ironing, cooking, washing dishes, planting a garden, and watering the lawn) are common in older adults. There were fewer Specific Activities in the other Major Headings, such as Dancing, Bicycling, Home repair, Inactivity, Sports, Occupation, and Self-care. One exception was Video games (a new Major Heading in the 2024 Adult Compendium). This result represents a growing interest over the last decade in using video games and other digital health modalities (e.g., Apps and online exercise programs) to increase PA levels in older people. More research is needed to measure the energy costs of PAs that are common in older adults, including activities of daily living (e.g., eating, bathing, dressing, shopping), providing other care (e.g., for grandchildren, older adults, and animals), leisure PAs (e.g., pickleball, golf, fishing, aquatic activities, recreational dancing, and outdoor bicycling), and the myriad of occupational activities undertaken by adults who continue paid work later in life.

Howley[21] provides historical evidence substantiating the use of a standard 3.5 mL/kg/min value or approximately 1.0 kcal/kg/h for one MET. Some researchers have noted, however, that using the standard MET underestimates the individual energy costs of PA in older adults because of differences in RMR.[11,16] Several studies have shown that RMR is lower in older adults and decreases with age.[9,11–14] Rather than using standard adult MET values for older adults, the OA Compendium uses MET_{60+} to reflect the actual energy costs of PA in adults ≥60 years. This new value provides a straightforward metric that will promote comparability across studies and can be widely used in epidemiological studies, PA assessment, exercise prescription, research, and practice.

PA energy costs in adults and older adults have been discussed in terms of differences in the relative (using a measured RMR) and absolute (using a standard RMR)

intensity of PA.[16,17,22] For example, Nagayoshi et al.[23] observed higher PA energy costs in older (60−80 years) as opposed to younger adults (20−59 years) across all 10 PAs that were measured, ranging from a 5% to a nearly 30% higher energy cost. These differences in energy cost are observed when a PA is held constant (e.g., walking speed) and when individuals are allowed to self-select their walking pace. Jones et al.[22] noted that energy cost was 15% higher in older adults than in younger adults when walking speed was held constant, and they observed a 23% lower walking speed in older adults when allowed to self-select their walking speed. These issues support the need for the MET_{60+} values and more research on the energy costs of PA in older adults.[24,25]

We recognize that some users of the OA Compendium may be interested in calculating a relative MET for older adults (PA in mL/kg/min divided by RMR mL/kg/min) to account for individual differences in age, height, weight, and sex. Relative METs can be calculated from MET_{60+} values (=MET_{60+} × 2.7 mL/kg/min /RMR mL/kg/min). For example, an individual with a measured RMR of 2.5 mL/kg/min, the relative value for code 0510060 (Home activities: making a bed, changing linens; MET_{60+} = 4.0) is 4.32, (4.0 × 2.7 / 2.5 = 4.3), about 8% higher than the standard MET_{60+} value. The Compendium website provides information for calculating corrected METs and a predicted RMR for adults ≥60 years using the methodology proposed by Kozey et al.[26] and Porter et al.,[27] respectively (https://pacompendium.com).

Classification of standard MET intensities is divided into 4 categories: sedentary behaviors (1.0−1.5 METs), light-intensity PA (1.6−2.9 METs), moderate-intensity PA (3.0−5.9 METs), and vigorous-intensity PA (≥6.0 METs). In the context of older adults' lower RMR and higher energy cost of PAs, additional research is needed to examine whether these intensity cut points are appropriate for MET_{60+} values. Exercise prescriptions that use standard adult METs with current MET intensity cut points in older adults may have too high an intensity, leading to overexertion, poor program adherence, and drop out.

Specific Activities and their associated MET_{60+} values presented here are from an extensive literature review of measured energy costs of PA in adults ≥60 years. Applying a resting energy cost of 2.7 mL/kg/min to account for a lower RMR in older adults, MET_{60+} provides a more accurate representation of the energy costs of PA in older adults. MET_{60+} values can be used to compare the energy costs of PA across studies, which will help to clarify dose−response relationships between PA and health outcomes. MET_{60+} values can also be used to develop PA intensity categories for older adults to help classify PA prevalence in older adults (e.g., percent engaging in moderate-to-vigorous intensity PA) and aid in PA programming for exercise prescription and rehabilitation settings.

Various factors influence RMR beyond age alone. Individual lifestyle, genetics, health status, height/weight, sex, body composition, and physical function variations can significantly impact older adults' RMR and the energy costs of PA. The OA Compendium does not account for these individual differences or environmental conditions, which may affect the accuracy of the MET_{60+} values. Also, Specific Activities in the OA Compendium can be performed at varying intensities, making them inherently more variable than walking at set speeds or doing other activities at similar efforts. The OA Compendium excludes older adults with physical disabilities and chronic diseases. This exclusion limits the generalizability of the findings to older adults with specific health conditions. Also, some activities in the OA Compendium have limited evidence, with 7-digit codes based on only 1 or 2 studies in some Major Headings. Increasing the number of studies in older adult populations will improve the robustness and reliability of the OA Compendium.

5. Conclusion

The OA Compendium presents the energy costs of 99 Specific Activities in adults aged ≥60 years. It enhances research and data collection efforts by providing a standardized framework with Major Headings, 7-digit codes, Specific Activities, and their associated MET_{60+} values; this allows for accurate comparisons of the energy costs of PA across studies in older adults. Researchers are encouraged to measure PA energy cost in older adults to expand our understanding of the relationship between PA and health outcomes. The OA Compendium supports tailored PA programs for older adults by better understanding and quantifying PA intensity, which may help with PA self-monitoring and goal setting. The website with supporting materials is located at https://pacompendium.com.

Acknowledgments

The authors thank librarian Jamie Conklin, who assisted with designing the review protocol and performed the database searches, and David Berrigan and Janet Fulton for reviewing this paper. We acknowledge Dr. William L. Haskell's insight in developing the Older Adult Compendium.

Authors' contributions

EAW designed the review protocol, monitored the review process, assigned MET_{60+} values, performed article screening, extracted data, drafted the manuscript, contributed to interpreting the findings, and revised the manuscript for intellectual content; SDH conceived the review, designed the review protocol, monitored the review process, assigned MET_{60+} values, performed article screening, extracted data, drafted the manuscript, contributed to interpreting the findings, and revised the manuscript for intellectual content; MH, CLK, TVB, and JMS performed article screening, extracted data, drafted the manuscript, contributed to interpreting the findings, and revised the manuscript for intellectual content; ZC, MQ, SAC, and WJB assisted with drafting the manuscript, provided critical feedback, contributed to interpreting the findings, and revised the manuscript for intellectual content; BEA conceived the review, assisted with drafting the manuscript, provided critical feedback, contributed to interpreting the findings, and revised the manuscript for intellectual content. All authors

have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

Appendix

Sample weights are applied to MET_{60+} values when multiple articles measure the same specific activity as represented by a 7-digit activity code. Sample weights are used to increase the precision of measured MET values by giving more weight to larger sample sizes. Two steps are applied. First, multiply the sample size from each article by their respective MET_{60} value. Second, divide that product by the sum of the sample sizes. An example is given for 4 articles with different sample sizes and MET_{60+} values (sample sizes = 20, 21, 98, and 118; MET_{60+} = 3.8, 5.3, 5.0, and 5.3, respectively).

Eq. 1. (Σ (sample size for each article × MET_{60+} value for each activity) / Σ (sample sizes for each article))

$$(\Sigma \quad (20 \times 3.8 + 21 \times 5.3 + 98 \times 5.0 + 118 \times 5.3) \quad / \quad \Sigma \ (20 + 21 + 98 + 118))$$

Weighted MET_{60+} = 5.069, rounded to 5.0.

References

1. Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of Physical Activities: Classification of energy costs of human physical activities. *Med Sci Sports Exerc* 1993;**25**:71–80.
2. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of Physical Activities: An update of activity codes and MET intensities. *Med Sci Sports Exerc* 2000;**32**(Suppl 9):S498–504.
3. Ainsworth BE, Haskell WL, Herrmann SD, et al. 2011 Compendium of Physical Activities: A second update of codes and MET values. *Med Sci Sports Exerc* 2011;**43**:1575–81.
4. Ridley K, Ainsworth BE, Olds TS. Development of a compendium of energy expenditures for youth. *Int J Behav Nutr Phys Act* 2008;**5**:45. doi:10.1186/1479-5868-5-45.
5. Butte NF, Watson KB, Ridley K, et al. A Youth Compendium of Physical Activities: Activity codes and metabolic intensities. *Med Sci Sports Exerc* 2018;**50**:246–56.
6. Herrmann SD, McMurray RG, Kim Y, Willis EA, Kang M, McCurdy T. The influence of physical characteristics on the resting energy expenditure of youth: A meta-analysis. *Am J Hum Biol* 2017;**29**:e22944. doi:10.1002/ajhb.22944.
7. McMurray RG, Butte NF, Crouter SE, et al. Exploring metrics to express energy expenditure of physical activity in youth. *PloS One* 2015;**10**: e0130869. doi:10.1371/journal.pone.0130869.
8. Pfeiffer KA, Watson KB, McMurray RG, et al. Energy cost expression for a Youth Compendium of Physical Activities: Rationale for using age groups. *Pediatr Exerc Sci* 2018;**30**:142–9.
9. Pontzer H, Yamada Y, Sagayama H, et al. Daily energy expenditure through the human life course. *Science* 2021;**373**:808–12.
10. Lyden K, Keadle SK, Staudenmayer J, Freedson P, Alhassan S. Energy cost of common activities in children and adolescents. *J Phys Act Health* 2013;**10**:62–9.
11. Leal-Martin J, Munoz-Munoz M, Keadle SK, et al. Resting oxygen uptake value of 1 metabolic equivalent of task in older adults: A systematic review and descriptive analysis. *Sports Med* 2022;**52**: 331–48.
12. Balke B. The effect of physical exercise on the metabolic potential, a crucial measure of physical fitness. In: Staley S, Cureton TK, Huelster LJ, Barry AJ, editors. *Exercise and fitness*. Chicago, IL: The Athletic Institute; 1960;8:141−2.
13. Karakelides H, Nair KS. Sarcopenia of aging and its metabolic impact. *Curr Top Dev Biol* 2005;**68**:123–48.
14. Manini TM. Energy expenditure and aging. *Ageing Res Rev* 2010;**9**:1–11.
15. World Health Organization. *Fact sheet: Ageing and health*. 2021. Available at: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. [accessed 15.06.2023].
16. Hall KS, Morey MC, Dutta C, et al. Activity-related energy expenditure in older adults: A call for more research. *Med Sci Sports Exerc* 2014;**46**:2335–40.
17. U.S. Department of Health and Human Services. *2018 physical activity guidelines: Advisory Committee scientific report*. Washington, DC: U.S. Department of Health and Human Services; 2018.
18. U.S. Department of Health and Human Services. *Physical activity guidelines for Americans midcourse report: Implementation strategies for older adults*. Washington, DC: U.S. Department of Health and Human Services; 2023.
19. Herrmann SD, Willis EA, Ainsworth BE, et al. 2024 Adult Compendium of Physical Activities: A third update of the energy costs of human activities. *J Sport Health Sci* 2024;**13**:6–12.
20. Piercy KL, Troiano RP, Ballard RM, et al. The Physical Activity Guidelines for Americans. *JAMA* 2018;**320**:2020–8.
21. Howley ET. Errors in MET estimates of physical activities using 3.5 mL/kg/min as the baseline oxygen consumption. *J Phys Act Health* 2011;**8**:141–2; author reply 3−4.
22. Jones LM, Waters DL, Legge M. Walking speed at self-selected exercise pace is lower but energy cost higher in older versus younger women. *J Phys Act Health* 2009;**6**:327–32.
23. Nagayoshi S, Oshima Y, Ando T, et al. Validity of estimating physical activity intensity using a triaxial accelerometer in healthy adults and older adults. *BMJ Open Sport Exerc Med* 2019;**5**:e000592. doi:10.1136/bmjsem-2019-000592.
24. Cai Z, Quan M, Huan M, et al. Energy costs of chair sitting and standing video exercises in Chinese older adults, ages 60 to 89 years. *Int J Exerc Sci* 2023;**16**:814–27.
25. Knaggs JD, Larkin KA, Manini TM. Metabolic cost of daily activities and effect of mobility impairment in older adults. *J Am Geriatr Soc* 2011;**59**:2118–23.
26. Kozey S, Lyden K, Staudenmayer J, Freedson P. Errors in MET estimates of physical activities using 3.5 mL/kg/min as the baseline oxygen consumption. *J Phys Act Health* 2010;**7**:508–16.
27. Porter J, Ward LC, Nguo K, et al. Development and validation of new predictive equations for the resting metabolic rate of older adults aged ≥ 65 y. *Am J Clin Nutr* 2023;**117**:1164–73.