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Original Article

Chinese Compilation of Physical Activities in healthy adults aged 18–64: Categories and metabolic intensities

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ABSTRACT

A Chinese Compilation of Physical Activities was compiled to estimate the energy costs of physical activities (PAs) using data on adults aged 18–64. Data were obtained from published articles and laboratory measurements. Databases, including PubMed, Embase, Scopus, Ebsco, Web of Science, Chinese National Knowledge Infrastructure, Wan Fang Data, National Science and Technology Report Service, Public Health Scientific Data were searched to collect data from inception to January 2022, on energy expenditure associated with PA in the healthy Chinese population. Two reviewers independently screened the literature and extracted, classified, and summarized data. Data were measured for 36 PAs using indirect calorimetry. Detailed descriptions of specific activities and metabolic equivalent values were provided by summarizing 241 physical activities in 13 categories. The first edition of the Chinese Compilation of PAs in Healthy Adults Aged 18–64(CCPA) was created. It provides valuable resources for people who regularly engage in physical exercise, researchers, educators, fitness professionals, and health or commercial sectors to quickly obtain various PA MET intensities. In the future, the energy expenditure of various PAs of different ages within the Chinese population can be measured based on the CCPA.

Introduction

In 2020, the World Health Organization (WHO) recommended that adults aged 18–64 engage in moderate-intensity aerobic physical activity (PA) to at least 150 min per week (min/wk) or 75 min/wk of vigorous-intensity aerobic PA or optimal health benefits. Doubling the amount of moderate- and vigorous-intensity aerobic PA to 300 min/wk and 150 min/wk, respectively, confers additional health benefits.[1] Global reports have shown that 27.5% of adults did not meet the PA levels recommended for PA and health.[2] The lack of energy expenditure caused by physical inactivity is a leading cause of chronic diseases and obesity.[3]

PA is defined as any bodily movement produced by skeletal muscles that require energy expenditure.[4,5] PA is a complex, comprehensive concept classified qualitatively based on function (occupation, sport, transportation, and housework) or quantitatively by intensity (sedentary, low, medium, and high).[6] In this study, the energy costs of PA in Chinese adults were evaluated directly or indirectly by measuring the energy expended in selected PAs or obtained by a search of the literature measuring the energy expenditure of PA in Chinese adults. In 1993, Ainsworth et al. published the first edition of the Compendium of Physical Activities (hereafter refer as Compendium). The Compendium is a comprehensive list of the energy costs of PA in healthy adults aged 16–65.[7] The Compendium lists the Metabolic Equivalent (MET) of PAs

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Abbreviations

CCPA	Chinese Compilation of Physical Activities
PA	Physical activity
MET	Metabolic equivalent
CISS	China institute of sport science
CNKI	Chinese national knowledge infrastructure

sorted by type and intensity as compiled from published literature or estimated when measured values are not found. The Compendium was updated in 2001 to form the second edition.[8] The latest version of the Compendium (3rd edition) was published in 2011, and a website was developed to provide a lookup for PA MET values and to download related resources.[9] The 2011 Compendium includes over 1 000 specific activities organized into 21 categories. Each specific activity has an associated MET value widely used by the general population, researchers, educators, fitness professionals, and the health or business sector. The Compendium is currently the most popular reference standard for PA research worldwide. However, the 2011 Compendium may not be entirely suitable as a reference standard for the PA energy expenditure of the Chinese population. The main reasons are as follows: 1) the Compendium is based on Western lifestyles, excluding traditional Chinese exercise such as Qigong and square dancing, 2) 260 (32%) specific activity MET values are estimated, and 3) some specific activity MET values may over-or underestimate PA in Chinese adults.[10]

Researchers have investigated PA's energy expenditure in Chinese adults. However, a reference standard for the energy expenditure of PA in Chinese adults has not been systematically established. The 2021 PA Guidelines for Chinese[6] issued by the Bureau of Disease Control and Prevention in 2021 and the Energy Expenditure of Sports and Fitness published in 2013 by the General Administration of Sport of China comprehensively elucidated the MET values of various PAs.[11] However, most of the data were based on the 2011 Compendium. The Chinese Dietary Guidelines, updated by the Chinese Nutrition Society in 2016, also listed some typical moderate- and high-intensity PAs but did not specify the associated MET values.[12] In 2013, the China Institute of Sport Science (CISS) began a project to measure the energy expenditure of PAs in Chinese populations. In the first stage of the project, the CISS measured and published the MET values of 7 PAs in 1 000 urban and rural residents.[13] In the following stage of the project, the energy expenditure of more than 60 typical PAs was measured and uploaded to the National Population Health Data Center (https://www.ncmi.cn/). However, the current data were undisclosed and not available to the public for ten years from the upload date.

The purpose of this study was to establish the Chinese Compilation of Physical Activities (CCPA) to provide a standardized and comprehensive reference standard for PA energy expenditure in healthy Chinese adults. We compiled energy expenditure data on PA in healthy Chinese adults aged 18–64, uniformly coding its function, categories, and intensity. The CCPA aims to provide references for PA interventions, fitness programs, or exercise prescriptions to meet the needs of clinical and epidemiological research in Chinese populations.

Material and methods

Literature search

A literature search was conducted in PubMed, Embase, Scopus, Ebsco, Web of Science, Wan Fang Data, and Chinese National Knowledge Infrastructure (CNKI) Data from inception to January 2022. Different possible variations or combinations of the keywords used were: “metabolic cost,” “calorimetry,” “energy metabolism,” “energy cost,” and “oxygen cost.” We also searched the Chinese National Science and Technology Reporting Service, Public Health Scientific Data. For example, the search strategy was developed in PubMed: ("calorimetry"[MeSH Terms] OR "calorimetry, indirect"[MeSH Terms] OR "energy metabolism"[MeSH Terms] OR "metabolic cost"[Title/Abstract] OR "oxygen cost"[Title/Abstract] OR "energy cost"[Title/Abstract]) AND ("China"[MeSH Terms] OR "Chinese"[Title/Abstract]).

Inclusion criteria for referenced articles include, 1) healthy Chinese adults aged 18–64, 2) data on PA energy expenditure was measured by indirect calorimetry (IC), and 3) literature for articles were published in English or Chinese. The studies that did not meet the inclusion criteria were excluded. The PRISMA diagram describes the selection process for studies (Fig. 1). The title, author, and year of the publication; characteristics of participants, including sex, age, weight, sample size, and energy expenditure; and experimental details such as measurement methods, activity duration, and specific activity description in the literature meeting the inclusion criteria were extracted. Two reviewers independently screened the literature, extracted, classified, and summarized data.

Measured PAs

To complement data from published articles, our laboratory measured the energy expenditure and calculated intensity categories for 36 of the 241 PAs in the CCPA (15%) frequently performed by Chinese adults. $n = 1\,494$ subjects residing near the testing site (age, 18–27 years) volunteered for the study. Subjects were asked to avoid alcohol, caffeine, and intense training for at least 24 h before all PA tests. Each PA test lasted 3–52 min in a laboratory (reading, walking, cleaning, folding clothes, video games, square dancing, resistance training, bicycling, recreation games, rope jumping, running) or a field setting (stair climbing and descending stairs, table tennis, tennis, badminton, Baduanjin, Tai Chi, Wuqinxi), depending on the PA type. We measured the energy expenditure with a portable indirect calorimetry system (Meta Max 3B, Cortex Biophysics Leipzig, Germany).[14] During laboratory experiments, the temperature was kept at 20 °C– 26 °C, and the relative humidity was kept at 20%–40%. During the field tests, the average ambient temperature was 15 °C– 26 °C. Every 10 s, the Meta Max 3B recorded oxygen consumption ($\dot{V}O_2$) and carbon dioxide output ($\dot{V}O_2$). The peak oxygen consumption or carbon dioxide production was defined as that which occurred with an RER greater or equal to 1.10 during any continuous 10 s period for all-out, maximal exertion.[15] METs were determined by dividing the measured peak $\dot{V}O_2$ of PAs in ml/kg/min by a resting $\dot{V}O_2$ of 3.5 ml/kg/min.

Coding scheme

The coding system for the CCPA consists of an eight-character alphanumeric Code, MET values, PA Categories, and Activity types (See Table 1 for the CCPA coding scheme).

Alphanumeric characters

An alphanumeric code (3 alphabetic and 5 numeric characters) was used to classify the PA category and activity types in the CCPA. The first three letters (CHN) are abbreviated for China. The letters are added to avoid confusion with the 5-digit code from the Compendium of PA. For the five numeric characters, the first two digits on the left represent the PA category, for example, “01” for “inactivity quiet/light” and “12” for “traditional Chinese exercise.” The last three digits on the right represent activity types in a PA category. For example, “008” in the “inactivity quiet/light” category (code 01) represents the PA activity “sitting, using a mobile (CHN01008)”. In category 12, “traditional Chinese exercise,” 010 represents the PA “Tai Chi, 24 forms of simplified, low posture (CHN12008)”. Code sorting is based on the Chinese Pinyin and Non-Chinese strings in the general sorting rules for text items (GB/T 13418-1992).

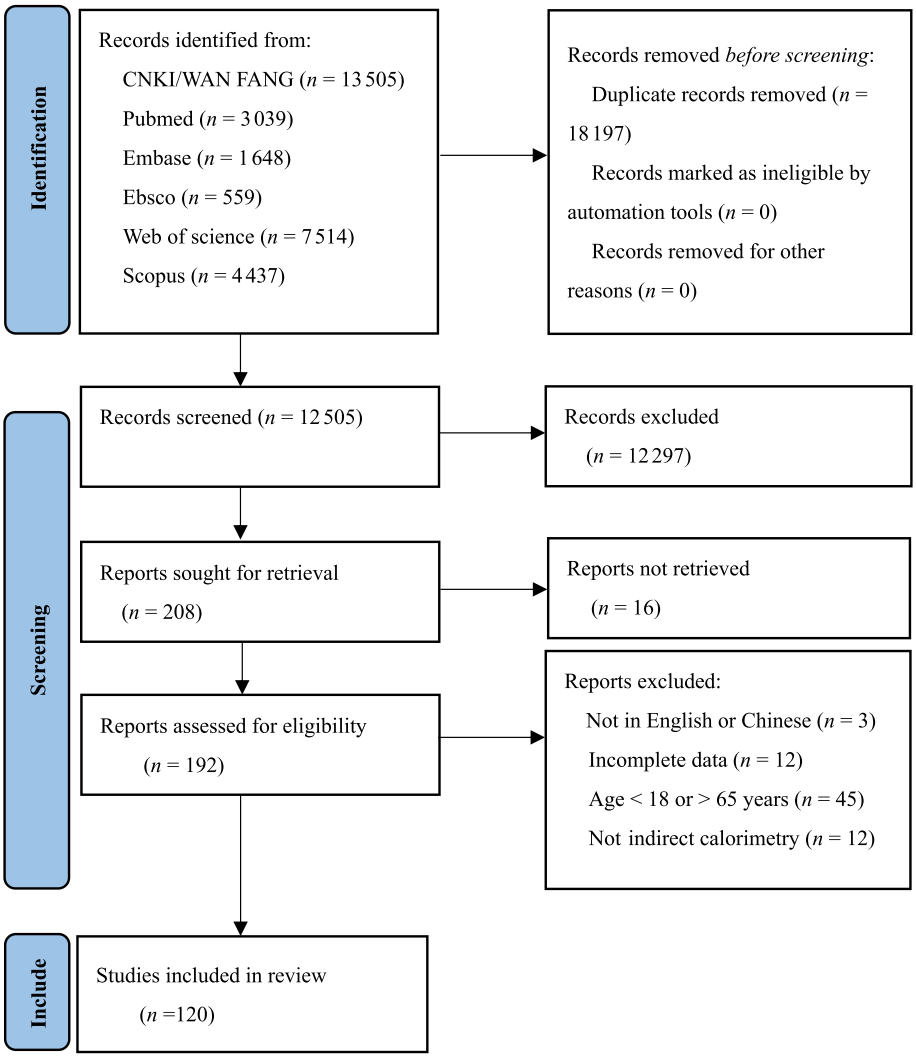

Fig. 1. PRISMA flow diagram.

Table 1
Examples of the Chinese Compilation of Physical Activities (CCPA).

Code	MET	Classification	Activity Types
CHN01008	1.2	inactivity quiet/light	Sitting, using a mobile
CHN12008	4.9	traditional Chinese exercise	Tai Chi, 24 forms simplified, low posture

PA categories

Assignment of PAs to the proper activity categories was the initial step in coding the CCPA. The CCPA categories describe the purpose of a PA. The CCPA contains 13 categories related to lifestyle PAs (inactivity quiet/light, walking, home activities, occupation, transportation) and physically active leisure-time PAs (bicycling, dancing, sports, running, conditioning and recreation, water activities, winter activities, and traditional Chinese exercise) (Table 2).

PA types

PA types are the individual activities within each category. Units for the activity types are presented as a percent effort or subjective intensity, speed in kilometers per hour (km/h), steps per minute (steps/min), cycle ergometer revolutions per minute (rpm), and watts (W), race format (kayak strokes/min), or factions of the activity intensity. Identification of the speed or intensity of a PA assists users in assigning the appropriate code and MET values accurately. PAs without an indication of the speed or intensity are listed as "general."

Table 2
Major types of physical activities in the Chinese Compilation of Physical Activities (CCPA).

Category number	Category	Category number	Category
01	inactivity quiet/light	08	water activities
02	walking	09	sports
03	winter activities	10	dancing
04	home activities	11	occupation
05	conditioning exercise	12	traditional Chinese exercise
06	transportation	13	bicycling
07	running		

MET values

METs are a simple, practical, easy-to-understand method for expressing PA energy expenditure. One MET is the ratio of the associated metabolic rate for a specific activity divided by a resting metabolic rate.

Table 3
Example of activity types in the CCPA.

Code	METs	Description	References
CHN05003	5.4	Square Dancing: Different Dances	Average of the following 6 measures
	4.40	"Zou Chu Da Shan"	Xiaolei Ji[25]
	7.23	"Bei Er Shuang"	Junqiang Qiu[26]
	5.51	"Ji Xiang Yao"	Junqiang Qiu[26]
	5.33	"Tao Hua Yao"	Junqiang Qiu[26]
	4.40	"Zhan Zai Cao Yuan Wang Beijing"	Xiu-juan Chen[27]
	5.70	"Wu Dong Zhong Guo"	Yan Lv[28]

The resting metabolic rate (energy expenditure) for sitting quietly in a chair is approximately 3.5 ml/kg/min. A 2-MET activity requires two times the energy expenditure of sitting quietly. METs can be converted into kilocalories (Kilocalories, kcal) or kilojoules (kilojoule, kJ), 1 MET = 1 kcal/kg/h = 4.184 kJ/kg/h.

All activities in the CCPA are assigned an intensity unit as METs (sedentary, ≤ 1.5 METs; light, 1.6–2.9 METS; moderate, 3–5.9 METs; vigorous, ≥ 6 METs). MET values were obtained from published literature and unpublished data measured in studies on Chinese populations. The MET value of a specific activity includes one decimal place in the CCPA. If there were 2 or more activities of the same or similar type, the final MET value was determined by the average of the MET value for the multiple activities. For example, code CHN05003 is the average value of 6 measurements (Table 3).

Calculation of kilocalorie energy expenditure

The energy expenditure values of specific activities have individual differences in the calculation related to body mass, age, and sex. The formula used for calculation is energy expenditure (kcal) = MET value (kcal/kg/h) × body mass (kg) × activity duration (h). For example, a 55 kg person performing a 24-form simplified Tai Chi expends 10.5 ml/kg/min (3 METs) twice a day for 30 min each time; the total daily energy expenditure of Tai Chi is calculated as follows: 3 METs × 55 kg × 0.5 h × 2 times/day = 165 kcal.

Results

The CCPA of Healthy Adults aged 18–64 includes an eight-character alphanumeric code that identifies 13 PA categories based on the purpose of PAs and 241 PA types and their associated MET values subsumed into a category. The number of PA types within a category differs depending on the availability of PAs measured. For example, category CHN05, "Conditioning exercise", includes 63 PA types, category CHN07, "running" includes 46 PA types, and category CHN12, "traditional Chinese exercise", includes 27 PA types. In comparison, category CHN03, "winter activities", and category CHN06, "transportation," include only three PA types each. The CCPA is presented in Table 4.

Table 4
Chinese Compilation of Physical Activities of healthy adults aged 18–64 (CCPA).

CODE	METS	CATEGORY	ACTIVITY TYPES
CHN01001	1.4	inactivity quiet/light	lying quietly, general[29–31]
CHN01002	1.6	inactivity quiet/light	standing quietly, general[29,32]
CHN01003	1.3	inactivity quiet/light	sitting quietly, general[29,32–34]
CHN01004	1.1	inactivity quiet/light	reading[35]
CHN01005	1.4	inactivity quiet/light	standing, reading[26]
CHN01006	1.4	inactivity quiet/light	sitting, watching television, or watching a movie[35]
CHN01007	1.3	inactivity quiet/light	sitting, using a computer[36]
CHN01008	1.2	inactivity quiet/light	sitting, using a mobile[36]
CHN01009	1.3	inactivity quiet/light	sitting writing[36]
CHN02001	3.3	walking	walking, 2.0 km/h, 2–4 min[29]
CHN02002	3.0	walking	walking, 3.0–3.8 km/h, 200 m[37–42]
CHN02003	3.5	walking	walking, 4.0 km/h[39,43,44]
CHN02004	3.8	walking	walking, 4.8 km/h[26,36–38,40–42,45]
CHN02005	4.4	walking	walking, 5.0 km/h[39,46,47]
CHN02006	4.6	walking	walking, 5.6–5.8 km/h[16,36,38,41,45,46,48]
CHN02007	5.5	walking	walking, 6.0–6.5 km/h[28,29,37,38,42,44–49]
CHN02008	7.2	walking	walking, 7.2 km/h[45,46]
CHN02009	9.1	walking	walking, 8.0 km/h[45]
CHN02010	9.9	walking	walking, 8.8 km/h[45]
CHN02011	6.4	walking	walking, different movement patterns (crawling, lunging, twisting between marching), moderate to high effort[50]
CHN02012	4.7	walking	walking, brisk speed[51]
CHN02013	2.5	walking	walking, slow frequency, 100 steps/min[52]
CHN02014	2.9	walking	walking, general[26,36]
CHN02015	4.2	walking	walking, optimum speed, 4.0–6.4 km/h[53]
CHN02016	17.2	walking	climbing hills, fast speed[54]
CHN02017	6.1	walking	climbing hills, slow speed[54,55]
CHN02018	8.7	walking	climbing hills, moderate speed[54,55]
CHN02019	3.7	walking	walking, carrying 15 kg load, 6.4 km/h[56]
CHN02020	2.2	walking	walking, carrying 25 kg load, 4.8 km/h[51]
CHN02021	11.7	walking	walking, carrying 25 kg load, 7.2 km/h[51]
CHN02022	5.1	walking	walking, carrying 4 kg load (vests, calves, feet), 5 km/h[33,57]
CHN02023	11.9	walking	6 min up and down the stairs test[58]
CHN02024	9.1	walking	stair climbing, 100 steps/min[10,59]
CHN02025	8.0	walking	stair climbing, 90 steps/min[20]
CHN02026	5.5	walking	stair climbing, carrying 1–5 kg load, moderate or vigorous effort[60]
CHN02027	11.4	walking	stair climbing,high-rise,fog haze weather[61]
CHN02028	5.1	walking	stair climbing, general[60]
CHN02029	7.7	walking	uphill, different gardens (10%, 3°, 6° and so on)[39,62]
CHN02030	4.7	walking	stair climbing and descending stairs, general[26,63]
CHN02031	3.9	walking	descending stairs, 100 steps/min[13,59]
CHN02032	5.9	walking	descending stairs, 12 levels of a building[61]

(*continued on next page*)

Table 4 (*continued*)

CODE	METS	CATEGORY	ACTIVITY TYPES
CHN02033	3.1	walking	descending stairs, 90 steps/min[27]
CHN03001	10.6	winter activities	speed skating, 1 000 m, simulation competition[64]
CHN03002	12.2	winter activities	speed skating, 1 500 m, simulation competition[64]
CHN03003	11.7	winter activities	speed skating, 500 m, simulation competition[64]
CHN04001	4.0	home activities	shopping, normal or using other tools, moderate effort[15]
CHN04002	1.7	home activities	kitchen activity, stirring, cutting vegetables, kneading dough, washing dishes, light effort[65]
CHN04003	2.7	home activities	making bed, changing beddings, general[15,65]
CHN04004	2.8	home activities	cleaning, scrubbing and cleaning the floor, sweeping the confetti, clearing trash, moderate effort[26,29,36,65]
CHN04005	2.6	home activities	mopping, general[49,63,65]
CHN04006	2.2	home activities	laundry, folding, hanging, ironing, washing clothes, light effort[15,26,36,63,65]
CHN04007	2.7	home activities	organizing room, desk, goods, light effort[29,36,63]
CHN05001	2.8	conditioning exercise	fixed postural exercising, planking, light effort[30]
CHN05002	4.4	conditioning exercise	radio gymnastics: ninth set[66–68]
CHN05003	5.4	conditioning exercise	square dancing, different dances (e.g., "out of the mountain, etc.")[25–28]
CHN05004	8.3	conditioning exercise	aerobics dancing, mass aerobics dancing 1–6 level, vigorous effort[69]
CHN05005	5.3	conditioning exercise	aerobics dancing, general[31]
CHN05006	3.9	conditioning exercise	resistance (weight) joint vibration training, 0%–80% of weight squats training, moderate effort[70]
CHN05007	3.5	conditioning exercise	resistance training, 0%–80% of weight squats training, moderate effort[70]
CHN05008	2.4	conditioning exercise	resistance training, 20%–80% of 1 RM squats training, single unit[26]
CHN05009	2.0	conditioning exercise	resistance training, 20%–80% of 1 RM benching, single unit[26]
CHN05010	1.7	conditioning exercise	resistance training, 4 kg benching, single unit[26]
CHN05011	2.1	conditioning exercise	resistance training, 4 kg squats training, single unit[26]
CHN05012	4.4	conditioning exercise	resistance training, single-action (benching training、bent-over rowing, bending the arm at the back of the neck, doing dumbbell preacher curls, benching), light to moderate effort[71]
CHN05013	6.7	conditioning exercise	resistance training, benching[72]
CHN05014	9.8	conditioning exercise	resistance training, weight squats, multiple groups[72]
CHN05015	7.9	conditioning exercise	resistance training, high strength double, multiple groups[29,73]
CHN05016	5.2	conditioning exercise	resistance training, behind-the-neck pulling over, multiple groups[72]
CHN05017	7.3	conditioning exercise	resistance training, fast cleaning and jerking, multiple groups[72]
CHN05018	5.2	conditioning exercise	resistance training, pulling the rubber band, multiple groups[72]
CHN05019	4.7	conditioning exercise	resistance training, lying prone to pull, multiple groups[72]
CHN05020	6.4	conditioning exercise	resistance training, bending the arm, multiple groups[72]
CHN05021	8.2	conditioning exercise	resistance training, sandbags on the left and right, multiple groups[72]
CHN05022	6.8	conditioning exercise	resistance training, raising hands and feet together, multiple groups[72]
CHN05023	8.3	conditioning exercise	resistance training, lifting kettlebells, multiple groups[72]
CHN05024	4.6	conditioning exercise	resistance training, benching, multiple groups[72]
CHN05025	2.5	conditioning exercise	resistance training, benching, general[30]
CHN05026	6.2	conditioning exercise	resistance training, dumbbell squat training, low to medium load, vigorous effort[71]
CHN05027	6.5	conditioning exercise	resistance training, push-up leg, multiple groups[72]
CHN05028	5.7	conditioning exercise	resistance training, sit-ups, multiple groups[72]
CHN05029	7.5	conditioning exercise	resistance training, lumbar abdomen turning, multiple groups[72]
CHN05030	8.0	conditioning exercise	resistance training, pulling-ups, multiple groups[72]
CHN05031	6.2	conditioning exercise	resistance training, standing up, multiple groups[72]
CHN05032	6.6	conditioning exercise	resistance training, composite moving (arms, chest, loin), medium load, vigorous effort[71]
CHN05033	5.0	conditioning exercise	resistance training. composite exercising (arms, chest, loin, legs), low load, moderate effort[71,74]
CHN05034	7.1	conditioning exercise	bicycling, stationary, 100 rpm/min, vigorous effort[29]
CHN05035	8.2	conditioning exercise	bicycling, stationary, 101–106 W, vigorous effort[26,75–77]
CHN05036	4.3	conditioning exercise	bicycling, stationary, 10–15 km/h, moderate effort[78]
CHN05037	7.1	conditioning exercise	bicycling, stationary, 125–190 W, variational effort[79]
CHN05038	9.3	conditioning exercise	bicycling, stationary, 161–200 W, vigorous effort[76,77]
CHN05039	6.1	conditioning exercise	bicycling, stationary, 18 km/h, vigorous effort[78]
CHN05040	11.9	conditioning exercise	bicycling, stationary, 201–207 W, very vigorous effort[77]
CHN05041	2.8	conditioning exercise	bicycling, stationary, 20–50 W, light effort[26,75,76]
CHN05042	4.6	conditioning exercise	bicycling, stationary, 37%–45% $\dot{V}O_{2max}$, light to moderate effort[80]
CHN05043	4.8	conditioning exercise	bicycling, stationary, 40%–60% $\dot{V}O_{2max}$, different time, moderate effort[81–83]
CHN05044	8.2	conditioning exercise	bicycling, stationary, 40% peak power[84]
CHN05045	6.2	conditioning exercise	bicycling, stationary, 46%–63% $\dot{V}O_{2max}$, moderate to vigorous effort[13,82]
CHN05046	5.4	conditioning exercise	bicycling, stationary, 51–89 W, light to moderate effort[26,75,76]
CHN05047	6.7	conditioning exercise	bicycling, stationary, 60%–85% $\dot{V}O_{2max}$, vigorous effort[81–83]
CHN05048	7.5	conditioning exercise	bicycling, stationary, 64%–91% $\dot{V}O_{2max}$, vigorous effort[80]
CHN05049	12.4	conditioning exercise	bicycling, stationary, 70% peak power[84]
CHN05050	5.3	conditioning exercise	bicycling, stationary, 70 rpm/min, moderate effort[29]
CHN05051	5.8	conditioning exercise	bicycling, stationary, 90–100 W, moderate to vigorous effort[75–77]
CHN05052	5.0	conditioning exercise	activity promoting video game (Nintendo Switch, Redmond, WA, USA), fitness ring exercising, vigorous effort[26]
CHN05053	2.6	conditioning exercise	activity promoting video game (Xbox 360 Kinect, Redmond, WA, USA), bowling, light effort[85]
CHN05054	4.9	conditioning exercise	activity promoting video game (Xbox 360 Kinect), table tennis, athletics, beach volleyball, moderate effort[85]
CHN05055	6.5	conditioning exercise	activity promoting video games (Xbox 360 Kinect), soccer, boxing、badminton, vigorous effort[85]
CHN05056	10.0	conditioning exercise	rope jumping, single rolling[26]
CHN05057	1.5	conditioning exercise	virtual reality, beam saber and so on, light effort[26]
CHN05058	4.5	conditioning exercise	virtual reality, boxing and so on, moderate effort[26]
CHN05059	8.5	conditioning exercise	blood restriction training, 40%–80% of blood restriction level, 40% $\dot{V}O_{2max}$[17]
CHN05060	7.3	conditioning exercise	aerobic exercises, several types, moderate to vigorous effort[36,79]
CHN05061	3.1	conditioning exercise	yoga, general[30]
CHN05062	3.6	conditioning exercise	calisthenics, push-ups, general, family fun and assistance, moderate effort[31]
CHN05063	9.4	conditioning exercise	calisthenics, leaping, vigorous effort[50]

(*continued on next page*)

Table 4 (*continued*)

CODE	METS	CATEGORY	ACTIVITY TYPES
CHN05064	4.5	conditioning exercise	calisthenics, light to moderate effort[71]
CHN05065	7.4	conditioning exercise	battle line training, 9–14 kg, waving hands, vigorous effort[86]
CHN06001	1.7	transportation	civilian pilot, on the flight (take off、level off、drop off)[87]
CHN06002	1.2	transportation	civilian pilot, sit for driving (on the ground and sky)[87]
CHN06003	3.2	transportation	civilian pilot, emergency flight[87]
CHN07001	11.9	running	incremental load running, exhaustive exercise[58,88]
CHN07002	11.3	running	high-intensity interval running, 5 × 4 min 90% $\dot{V}O_{2max}$[89]
CHN07003	9.0	running	high-intensity interval running, 6 × 30 s 100% $\dot{V}O_{2max}$[89]
CHN07004	6.7	running	exercising for 20 min, resting for 10 min, 3 groups[90]
CHN07005	5.5	running	running, 160 steps/min[52]
CHN07006	5.8	running	jogging, 3% slope, 5.6 km/h, moderate effort[62]
CHN07007	9.4	running	jogging, 3% or 6% slope, 5.61–8.02 km/h, vigorous effort[62]
CHN07008	14.5	running	running, 100% of anaerobic threshold intensity[91]
CHN07009	15.0	running	running, 105% of anaerobic threshold intensity[91]
CHN07010	16.6	running	running, 110% $\dot{V}O_{2max}$ intensity[92]
CHN07011	15.6	running	running, 110% of anaerobic threshold intensity[91]
CHN07012	16.3	running	running, 115% of anaerobic threshold intensity[91]
CHN07013	10.1	running	running, 12 km/h[93,94]
CHN07014	16.7	running	running, 120% of anaerobic threshold intensity[91]
CHN07015	10.1	running	running, 13 km/h[89]
CHN07016	10.4	running	running, 14 km/h[89]
CHN07017	10.9	running	running, 15 km/h[89]
CHN07018	12.7	running	running, 16 km/h[91,93]
CHN07019	13.2	running	running, 1 km running at full effort, 15–50 kg load[34,57]
CHN07020	14.1	running	running, 1 km running at full effort, no load[34,57]
CHN07021	4.8	running	running, 4.8–5 km/h[46,95]
CHN07022	6.2	running	running, 40% $\dot{V}O_{2max}$[26,33]
CHN07023	6.5	running	running, 5.6–6.4 km/h[36,46,62,95]
CHN07024	8.3	running	running, 50% $\dot{V}O_{2max}$[26,92]
CHN07025	8.9	running	running, 55% $\dot{V}O_{2max}$[84,96,97]
CHN07026	10.3	running	running, 60% $\dot{V}O_{2max}$[33,92,96,98]
CHN07027	10.9	running	running, 65% $\dot{V}O_{2max}$[96,99,100]
CHN07028	8.1	running	running, 7 km/h[26,39,46,101]
CHN07029	11.5	running	running, 70% $\dot{V}O_{2max}$[26,92,96]
CHN07030	10.4	running	running, 70% of anaerobic threshold intensity[91]
CHN07031	8.5	running	running, 8 km/h[26,31,36,37,39,40,42–44,48,57,62,95,101,102]
CHN07032	13.1	running	running, 80% $\dot{V}O_{2max}$[26,33,92,99]
CHN07033	12.0	running	running, 80% of anaerobic threshold intensity[91]
CHN07034	9.6	running	running, 9–11 km/h[26,31,37,93,94,101,103,104]
CHN07035	15.6	running	running, 90% $\dot{V}O_{2max}$[92]
CHN07036	13.4	running	running, 90% of anaerobic threshold intensity[91]
CHN07037	14.0	running	running, 95% of anaerobic threshold intensity[91]
CHN07038	11.0	running	running, running in different directions[89,105]
CHN07039	7.5	running	running, high temperature and humidity environment, 40% $\dot{V}O_{2max}$[33]
CHN07040	10.8	running	running, high temperature and humidity environment, 60% $\dot{V}O_{2max}$[33]
CHN07041	13.4	running	running, high temperature and humidity environment, 80% $\dot{V}O_{2max}$[33]
CHN07042	11.2	running	running, individual anaerobic threshold intensity[89]
CHN07043	6.9	running	running, intervals running, 55% $\dot{V}O_{2max}$[97]
CHN07044	10.6	running	running, basketball (striker, forward, fullback), 10 km/h[104]
CHN07045	4.7	running	running, general[30]
CHN07046	6.5	running	running, maximum fat oxidation rate, moderate to vigorous effort[50]
CHN08001	12.8	water activities	canoeing, 80%–100% of intensity (32–42 strokes/min)[72]
CHN08002	11.7	water activities	kayaking, 80%–100% of intensity (32–42 strokes/min)[72]
CHN08003	12.5	water activities	rowing, single oar, 80%–100% of intensity (32–42 strokes/min)[72]
CHN08004	12.8	water activities	rowing, sculls, 80%–100% of intensity (32–42 strokes/min)[72]
CHN09001	12.4	sports	rugby, fallback, striker, fullback[106]
CHN09002	6.1	sports	basketball, general[30,36]
CHN09003	4.1	sports	volleyball[30]
CHN09004	6.6	sports	table tennis, simulation competition[26,107]
CHN09005	7.0	sports	table tennis, different frequency forward and backhand arc shot, vigorous effort[108]
CHN09006	5.1	sports	table tennis, backhand attack and block[109]
CHN09007	4.7	sports	sanda[30]
CHN09008	5.6	sports	wrestling[36]
CHN09009	9.3	sports	tennis, different technique shotting, low velocity[110]
CHN09010	9.4	sports	tennis, different technique shotting, high velocity[110]
CHN09011	12.5	sports	tennis, running and swinging at different speeds, vigorous effort[29]
CHN09012	9.3	sports	tennis, all phases of the stroke synthesis, on 30 km/h and 60 km/h ball speed[111]
CHN09013	8.9	sports	tennis, single competition[111]
CHN09014	11.1	sports	badminton, different frequency, and interval footwork exercises[94]
CHN09015	10.0	sports	badminton, simulation competition[26,94]
CHN09016	7.4	sports	badminton, general[112]
CHN09017	4.7	sports	soccer, juggling, double pass, dribbling-crossover[30]
CHN09018	9.1	sports	soccer, frontline, competition[113]
CHN09019	2.8	sports	soccer, goalkeeper, competition[113]

(*continued on next page*)

Table 4 (*continued*)

CODE	METS	CATEGORY	ACTIVITY TYPES
CHN09020	9.7	sports	soccer, left back, competition[113]
CHN10001	9.8	dancing	ballet, solo dance[26]
CHN10002	8.4	dancing	solo dancing, song, and dance troupe performance[26]
CHN10003	11.0	dancing	African dancing, member of oriental song and dance troupe[26]
CHN10004	11.7	dancing	Latin American dancing, member of oriental song and dance troupe[26]
CHN10005	7.0	dancing	Latin dancing, silver medal routine[31]
CHN10006	7.9	dancing	duo dancing, song, and dance troupe performance[26]
CHN10007	5.9	dancing	dance bar movement, ballet, folk[26]
CHN10008	8.3	dancing	dance basic skills training course, ballet, folk[26]
CHN10009	4.9	dancing	dance preparation activities, ballet, folk[26]
CHN10010	1.7	dancing	dance bar movement, ballet, folk[114]
CHN11001	3.9	occupation	mineworkers, pushing empty cart[115]
CHN11002	8.4	occupation	mineworkers, pushing heavy cart[115]
CHN11003	6.4	occupation	coal mining, mineral separation, vigorous effort[116]
CHN11004	5.1	occupation	coal mining, erecting supports, walking up and down hills, striking cones, and so on, moderate effort[116]
CHN11005	2.7	occupation	coal mining, walking, pneumatic drill, light effort[116]
CHN11006	2.4	occupation	farming, pulling seedlings, planting vegetables, sowing, shoulder carrying empty barrels, cutting vegetables, etc., light effort[116]
CHN11007	3.9	occupation	farming, cart, fertilization, transplanting, hoeing, watering, shoulder load, etc., moderate effort[116]
CHN11008	3.8	occupation	firefighter, military physical fitness (water belt exercise, load running, load climbing, etc.), moderate effort[117]
CHN11009	4.1	occupation	shipyard working, carpentry, batch shovel, up and down the cabin, hammering, etc., moderate effort[116]
CHN11010	1.7	occupation	shipyard working, gas heating, gas cutting, electric welding, turning, handle hammer, etc., light effort[116]
CHN11011	1.7	occupation	Sitting, typewriting[29]
CHN12001	3.1	traditional Chinese exercise	Baduanjin[26,30,66,118]
CHN12002	6.2	traditional Chinese exercise	aerobic Yangge dance: sixth set[118,119]
CHN12003	4.4	traditional Chinese exercise	aerobic Yangge dance: fifth set[118]
CHN12004	2.2	traditional Chinese exercise	Liuzijue[118]
CHN12005	6.4	traditional Chinese exercise	Miao drums[47]
CHN12006	4.5	traditional Chinese exercise	Tai Chi sword: 32 forms[120]
CHN12007	2.6	traditional Chinese exercise	Tai Chi sword: general[30]
CHN12008	4.9	traditional Chinese exercise	Tai Chi, 24 forms simplified, low posture[121,122]
CHN12009	3.8	traditional Chinese exercise	Tai Chi, 24 forms simplified, high posture, different level[121,122]
CHN12010	4.2	traditional Chinese exercise	Tai Chi, 24 forms simplified, moderate posture[121]
CHN12011	3.9	traditional Chinese exercise	Tai Chi, 24 forms simplified, free style posture[26]
CHN12012	3.1	traditional Chinese exercise	Tai Chi, ba bu wu fa[73]
CHN12013	7.3	traditional Chinese exercise	Tai Chi, split action (push hand), vigorous effort[123]
CHN12014	3.1	traditional Chinese exercise	Tai Chi, split action (cloud hands), vigorous effort[122]
CHN12015	6.7	traditional Chinese exercise	Tai Chi, split action (cloud hands), athletic wushu serials[124]
CHN12016	3.2	traditional Chinese exercise	Tai Chi, 32 forms modified[73,125]
CHN12017	3.8	traditional Chinese exercise	Tai Chi, general[73]
CHN12018	3.5	traditional Chinese exercise	Tai Chi softball[126]
CHN12019	3.4	traditional Chinese exercise	Wuqinxi, general[26,118,127]
CHN12020	5.1	traditional Chinese exercise	Wuqinxi, Chinese five-animal gymnastics
CHN12021	4.4	traditional Chinese exercise	martial arts, single sword, gunshu, jianshu, quanshu[30]
CHN12022	3.4	traditional Chinese exercise	martial arts, general[30]
CHN12023	5.5	traditional Chinese exercise	dragon dance[30]
CHN12024	4.8	traditional Chinese exercise	lion dance[30]
CHN12025	3.2	traditional Chinese exercise	yijinjing[118]
CHN13001	3.6	bicycling	bicycling, 10 km/h[128]
CHN13002	3.9	bicycling	bicycling, 12 km/h[44,102]
CHN13003	4.4	bicycling	bicycling, 13 km/h[128]
CHN13004	5.5	bicycling	bicycling, 15 km/h[128]
CHN13005	6.5	bicycling	bicycling, 18 km/h[128]

Discussion

The CCPA lists the energy expenditure of PAs in Chinese adults obtained from the published literature and measured in the laboratory. The CCPA contains an eight-character alphanumeric code that describes the assignment of 241 PA types with their associated MET values into 13 categories according to the purpose of the activity. The first three characters of the alphanumeric code indicate the origin of the CCPA (CHN, China), the first and second numeric digits indicate the PA category, and the last three numeric digits indicate the PA type within a category. The CCPA includes lifestyle (e.g., inactivity/quiet/light, transportation, occupation, and home activities) and conditioning activities (e.g., walking, bicycling, running, sports, general conditioning, and water sports) regularly performed by Chinese adults. The uniqueness of the CCPA is that it also includes a category for traditional Chinese exercise (category 12) that contains various forms of Tai Chi, dances, and martial arts.

The CCPA was developed to assign the energy cost of PAs in Chinese adults aged 18–64 years. The most prominent feature of the CCPA is that the MET values were obtained from energy expenditure measured in healthy Chinese adults. Of the 241 activity types in the CCPA, 205 (85%) were obtained from the published literature, and 36 (15%) were measured in our laboratory. Energy expenditure values range from 1.2 METs for sitting and using a mobile phone to 17.2 METs for climbing hills at a fast speed. Of the activity types, 10 (4%) are classified as sedentary behaviors ($\leq$ 1.5 METs), 27 (11%) are light intensity (1.6–2.9 METs), 82 (34%) are moderate intensity (3.0–5.9 METs, and 122 (51%) are vigorous intensity ($\geq$ 6 METs). Associating the MET values with intensity classifications provides health professionals a resource to identify types of activities suitable for adults of different ages and physical abilities. The CCPA is also useful for public health surveillance and research in Chinese populations to assign MET values in PA questionnaires.

Researchers in China have gradually grown to value the application and popularity of the Compendium of PA. Since 1993, the Compendium has been the only resource to assign MET values for various activities. In 2020, the 2011 Compendium was translated and published in Chinese for use in Chinese populations.[16] The 2011 Compendium (Chinese-English version) can be downloaded from the Compendium website (https://sites.google.com/site/compendiumofphysicalactivities/compendia).

For decades, Chinese scholars have been active in identifying PA energy expenditure, from the investigation and research on the energy expenditure of multiple occupations to the National Key Technology Support Program initiated in 2009.[13] They also have been active in basic data measurement tasks to measure PA energy expenditure for the National Key R&D Program (2018).[17] Such measures are included in the CCPA, coined as PAs with Chinese characteristics. For example, energy expenditure measurements of Tai Chi, Baduanjin, broadcast calisthenics, Wuqinxi, dragon dancing, and other uniquely Chinese PA increases the relevance of the CCPA for Chinese populations. The CCPA supplements the few PAs in the Compendium of PA that pertains to Chinese populations. The latest "Guidelines for PA for Chinese Adults (2021)" issued by the Chinese Ministry of Health's Bureau of Disease Control and Prevention cites MET values from the 2011 Compendium for use in their tasks. Due to differences in the PA types, methods, and populations used to measure PAs, MET values are not interchangeable between the Compendium and the CCPA. Hopefully, the CCPA will be considered a culturally relevant resource for national organizations. Therefore, the important historical significance of this study is that it establishes a CCPA suitable for the Chinese population based on the PA energy expenditure data of the Chinese population.

Like the Compendium of PA,[7–9] most data in the CCPA comes from published information. Data also are from the indirect calorimetry measurements from the 2018–2022 National Key R&D Program, including walking, running, cycling, 24 forms of simplified Tai Chi, Health Qigong Baduanjin, Health Qigong Wuqinxi, strength and conditioning, skipping rope, resistance training (e.g., squats), skipping rope, table tennis, badminton, tennis, Nintendo exergaming and other activities.[17]

Currently, the CCPA targets the population aged 18–64 to correspond to the age group division from the PA Guidelines for the Chinese Population,[6] the WHO Guidelines on PA and Sedentary Behaviours,[1] and the U.S. PA Guidelines 2nd edition.[18] Due to the lack of PA energy expenditure data for Chinese preschool children, adolescents, and the elderly, it is difficult to present a CCPA for these groups at this time. For related research, the PA compilation of preschool children by Brandes[19] and Puyau[20] et al. and the Youth Compendium of Physical Activities[21] are excellent references for children and adolescents.

Limitations and future plans

The most valuable role of CCPA is that it provides a classification system for PAs with associated MET values specific to Chinese adults. However, neither the Chinese version nor the Compendium of PA can fully assess the actual energy expenditure of PAs[9] as the accuracy of CCPA can be affected by several factors. First, inconsistencies in the way data are collected between studies may increase variability in MET values for activity types, especially when MET values are averaged across studies for similar modes of PA. Second, descriptions of some PAs do not contain all the details about PAs needed to identify the context of an activity. For example, the CCPA entry, "CHN09016, 7.4 METs, sports, badminton general," is so brief that it is impossible to identify whether the alphanumeric code represents singles or mixed doubles, competitive or recreational games. Third, individual differences exist in performing the same PA by weight, age, sex, activity efficiency, suitability for particular circumstances, and reported PA patterns. Forth, the CCPA is not suitable for people with mobility impairments and those in wheelchairs. For related research, readers are referred to Conger et al.'s list of MET values for the population using manual wheelchairs.[22]

When using the CCPA MET values used to calculate the total energy expenditure of individuals, the resultant kilocalorie values represent only an estimate of the energy expenditure of a PA. Further, the excess post-exercise oxygen consumption in high-intensity sporting activities is often ignored when measuring the oxygen consumption of PAs. This omission can lead to an underestimation of the total energy expenditure,[23] especially for short-term exercise.

Plans for the CCPA are to continue collecting and updating values for the energy expenditure of PAs in Chinese persons in all age groups. Our focus will include collecting data for traditional Chinese sports (such as dragon boat, dragon and lion dance, shuttlecock, croquet, martial arts, sports dance, and kite sports), with all PA data derived from actual measured energy expenditure data. We also aim to establish a proprietary Mandarin language website to promote, disseminate, and popularize the CCPA and encourage research institutions and scholars to submit research reports to the website. Furthermore, we will seek more journal and data platform collaborations to attract unpublished relevant studies regarding the PA energy expenditure in Chinese populations. This plan is modeled after the 2015 Working Group on the Youth Compendium of Physical Activities that collected 17 manuscripts, including data for children and teenagers aged 3–18, and published the information in a special supplement to the *Journal of Physical Activity and Health*.[24] Lastly, if there are many data sources, we will evaluate MET values for the same PAs using evidence-based and meta-analysis to increase the CCPA accuracy further.

Conclusions

The CCPA uses an eight-character alphanumeric code to organize 241 PAs and their associated MET values in 13 categories for use in healthy Chinese adults aged 18–64. MET values were obtained by reviewing the Chinese literature and from PA energy expenditure measurements. The CCPA provides a valuable resource for Chinese people who regularly engage in PA, researchers, educators, fitness professionals,

and health or business sectors to quickly obtain MET values for various levels of PA. The CCPA also is helpful for those developing PA or dietary guidelines for residents, PA interventions, fitness programs, and exercise prescriptions.

Submission statement

This manuscript has not been published or presented elsewhere in part or entirety. Its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and, if accepted, it will not be published elsewhere without the written consent of the copyright holder, including electronically in the same form. An Chinese version of CCPA was published in the fifth issue of *Chinese Journal of Sports Medicine*. The study design was approved by the appropriate ethics review board. We have read and understood your journal's policies, and we believe that neither the manuscript nor the study violates any of these.

Authors' contributions

Conceptualization, J.Q., Z.Q., and W.Z.; methodology, J.Q., J.Y., L.M., Y.C., C.X., and H.L; investigation and resources, J.Y., L.M., Y.C., X.G., Y.W., Y.Y., H.L., and Z.Q; writing and editing, J.Q., J.Y., L.M., Y.C., C.Y., and B.E, A.; project administration, J.Q., L.M., C.H., L.F., and Q.Z.; funding acquisition, J.Q., Y.Y., and Q.Z.; supervision, J.Q., Y.Y., and Q.Z. All authors read and approved the manuscript.

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Ethical approval statement

Each subject was required to fill out an informed consent form to understand the details and specific requirements of the test. The study measuring the oxygen consumption of selected PAs was approved by the Institutional Review Board of Beijing Sport University (No. 2019099H).

Data availability statement

The datasets generated and/or analyzed as part of the current study are not publicly available due to confidentiality agreements with funders. However, they can be made available solely for review and not for publication from the corresponding author upon reasonable request.

Conflict of interest

The author declares no conflicts of interest relevant to the content of this paper.

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