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RESEARCH ARTICLE **OPEN ACCESS**

Muscle Strength and Physical Fitness of Young People Living with Perinatal HIV in Northern Thailand

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Abstract:

Introduction: Currently, many young people living with perinatally-acquired HIV (YPHIV) are adults. Living with HIV and chronic use of antiretroviral medication might increase the risk of metabolic and cardiovascular diseases and affect the physical fitness of individuals. This study assessed muscle strength and functional exercise capacity in YPHIV patients in Thailand.

Methods: The cross-sectional study was conducted at Chiang Mai University. Inclusion criteria were 1) YPHIV aged 16-30 years, 2) having perinatal HIV infection, and 3) receiving antiretroviral treatment and being clinically healthy. Those with active concurrent illnesses or physical disabilities were excluded. Anthometric measurements were performed, and data were collected using self-administered questionnaires. Handgrip strength was measured using a digital handgrip dynamometer (TKK 5401; Takei, Japan), with Korean reference ranges used. The six-minute walk test (6MWT) was performed to assess functional exercise capacity. The regression equation from a Singaporean study was adopted to calculate predicted values.

Results: Thirty-four YPHIV were included; 19 (56%) were female. Their median age was 23.5 years (interquartile range, IQR 19.8, 26.6), and their median body mass index was 21.7 kg/m^2 (IQR 18.6, 24.2). The median handgrip strength was 23.8 kilograms (IQR 20.8, 30.3) in females and 33.6 kilograms (IQR 26.1, 40.2) in males. There were 10 (29%) participants with suboptimal handgrip strength and 1 (2.9%) with low handgrip strength. The median 6-minute walk distances were 489 meters (IQR 447, 523) in females and 536 meters (IQR 485, 568) in males. 6 participants (18%) had walking distances < 10% of their predicted values.

Discussion: It was demonstrated that around two-thirds of YPHIV had optimal muscle strength, as most of them were found to have good physical fitness. Suboptimal strength in some participants could be related to HIV and its treatment, as well as other social factors. As low muscle strength was identified as a marker of cardiovascular risk and related to metabolic syndrome, YPHIV could benefit from age-appropriate exercise to minimize long-term health consequences.

Conclusion: Despite being clinically healthy and having good physical fitness, nearly one-third of YPHIV had suboptimal muscle strength for their age and gender. Physical activities and muscle-strengthening exercises should be encouraged.

Keywords: Handgrip strength, Physical fitness, Young people, Perinatal HIV, Living with HIV, Muscle-strengthening exercises.

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1. INTRODUCTION

Increasing evidence suggests young people living with HIV are at an increased risk of metabolic syndrome [1], premature cardiovascular disease [2], and early-onset sarcopenia in adulthood [3]. In Thailand in 2024, an estimated 27,000 young people between 15 and 24 years of age were living with HIV [4]. Adolescents and young adults living with perinatally-acquired HIV in Thailand are now growing up with prolonged use of Antiretroviral Treatment (ART), and the continuous need for lifelong therapy [5]. Since the second decade of life, some of those young people have had metabolic changes associated with an increased risk of cardiovascular diseases [6, 7]. Entering adulthood, they transitioned into adult services, joining a cohort of young people with non-perinatally acquired HIV. While embedded in adult care, with similar ages, young people with Perinatal HIV (YPHIV) have been living with the virus and ART for a longer duration. Living with HIV is associated with increased risk of cardiovascular and metabolic disorders from traditional risk factors, HIV viremia, and exposure to ART [8-10]. Using conventional age cut-off criteria or age-based risk score calculations, they would be considered to be in the low cardiovascular risk group. There are no biomarkers to further predict or guide clinical monitoring for emerging adverse events or health deterioration related to chronic inflammation and immune activation. With effective ART, currently, most YPHIV are clinically well, with good physical appearance and social functions [11]. Both chronic inflammations related to HIV infection and ART treatment increase sarcopenia risk through several paths, including changes in protein synthesis and breakdown in skeletal muscle tissue related to immune activation [3, 12]. However, healthcare providers do not assess muscle strength and physical fitness during regular HIV care, unless anyone has musculoskeletal or neurological complaints. Extrapolated from adult studies, handgrip strength is a measure of muscle strength reported to be associated with metabolic syndrome [13], cardiovascular disease [14], and multiple chronic diseases and morbidity [15]. Simple functional exercise capacity tests are widely used to assess physical fitness reflecting cardiopulmonary function in patients with many chronic health conditions [16]. Previous studies used the 6-minute walk test in people living with HIV reported decreased distance when compared to uninfected individuals [17, 18]. However, limited data from research in young people living with HIV, especially those with perinatally acquired infection. Muscle strength varies by sex and body build; males are expected to be stronger than females of the same age [19]. Knowing the baseline muscle strength and functional capacity during young adulthood might be useful for monitoring and guiding health behavior counseling. It was hypothesized that YPHIV might have decreased muscle strength and impaired physical fitness, which could be associated with cardiometabolic risks. In this study, handgrip strength was measured, and the six-minute walk test was performed in YPHIV.

2. METHODS

The cross-sectional study was conducted at Chiang Mai University in March 2025. The Inclusion criteria were 1) YPHIV aged 16-30 years, 2) having perinatal HIV infection, and 3) receiving ART from the National AIDS Program at HIV clinics and being clinically healthy. Those with active concurrent illnesses or physical disabilities were excluded. Study participants were recruited by outreach workers through community networks when they gathered for another focus group activity at HIV clinics in Chiang Mai city and neighboring areas. Some of them were initiated on ART in their infancy period, while some started treatment later during early childhood to pre-adolescent years. All participants have been on ART for at least 10 years and were either studying or working to earn a living at the time of the study. Thus, healthy YPHIV residing in communities were represented. For sample size estimation, a Brazilian study reported that 24% of young people living with HIV had intermediate or weak grip strength [20], and a slightly higher proportion was expected to be observed in the present study population, who had perinatally acquired infection since childhood. This study includes a total of 34 participants. Assuming that the proportion of the outcome of interest (suboptimal muscle strength) is 30%, a 95% confidence interval (CI) estimated using the normal (Wald) approximation would be approximately 14.6 to 45.4%. The study was approved by the institutional review board at Research Institute for Health Sciences, Chiang Mai University (Certificate approval number 80/2024). Before enrollment, participants provided written informed consent; for those under 20 years of age, consent and assent were obtained from the caregiver and the participant, respectively. Self-administered questionnaires were used to collect demographic data, alcohol use, smoking, lifestyles, and exercise habits. Anthropometric measurements included body weight and height, using standard procedures. Blood pressure was measured at baseline and interpreted according to the Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults [21].

Handgrip Strength (HGS) was measured by a trained research nurse using the digital hand grip dynamometer (TKK 5401; Takei, Japan). Participants were asked to hold the dynamometer in the dominant hand, with the arm at right angles and the elbow by the side of the body. The handle of the dynamometer was adjusted so that the base rested on the palm heel and the handle was at the middle of the four fingers. When prompted, the participants were instructed to squeeze the dynamometer with maximum effort and maintain for about 5 seconds, while not moving other body parts [22]. The Korean age-sex-specific reference ranges were used for interpretation [23]. We defined the values less than mean-1SD and mean -2SD as suboptimal and low handgrip strength, respectively. The six-minute walk test (6MWT) was performed to assess physical fitness or functional exercise capacity. The 6MWT was conducted along a 30-metre walkway. Participants were instructed to “walk as far as possible in 6 minutes”

back and forth and turn around the cone that marked the ends of the walkway. They could slow down or rest if necessary. Heart rate and oxygen saturation were measured before and after the walk. The regression equation from a Singaporean study was adopted to calculate predicted values [24]. The maximal oxygen consumption (VO_2 max) was calculated. The Indian healthy young adults' normative reference value was adopted for interpretation [25].

Statistical analysis was performed using IBM SPSS Statistics version 23 (Statistical Package for Social Science Japan, Inc, Tokyo, Japan). Variables are described in number (%) or median (interquartile range). Analysis was performed separately for females and males using the normal reference range for each sex. For each participant, body mass index (BMI), the HGS-to-body weight ratio, the HGS-to-BMI ratio, and metabolic equivalent time (MET) from walking distance were calculated to estimate functional capacity [26]. The maximum oxygen consumption (VO_2 max) during 6-minute walk test was calculated to evaluate aerobic fitness using the following eq. (**1**) [27]:

$$VO_2 \text{ max (mL·kg(-1)·min(-1))} = 70.161 + (0.023 \times \text{6MWT [m]}) - (0.276 \times \text{weight [kg]}) - (6.79 \times \text{sex, where m = 0, f = 1}) - (0.193 \times \text{resting HR [beats per minute]}) - (0.191 \times \text{age [y]}) \quad \textbf{(1)}$$

3. RESULTS

Thirty-four YPHIV were included; 19 (56%) were female. Their median age was 23.5 years (interquartile range, IQR 19.8, 26.6). Half of them finished school and worked full-time, 12 (35%) were studying for their bachelor's degree, or graduated. The median body mass index was 21.7 kg/m^2 (IQR 18.6, 24.2). The median waist circumferences were 74 centimeters (IQR 70, 83) in females and 79 (IQR 69, 84) in males. There were 10 (29%) of YPHIV in this study with stage 1 hypertension, including 8 males (53%), and 2 females (10%). Four (13%) reported being current smokers (cigarette or e-cigarette), 16 (53%) drank alcohol occasionally, while 8 (27%) and 2 (7%) drank 1-2 times a month and 1-2 times a week, respectively. Ten (33%) reported rarely exercising, 14 (47%) exercised occasionally, and 6 (20%) exercised 1-2 times a week (Table **1**).

The median HGS was 23.8 kilograms (IQR 20.8, 30.3) in females and 33.6 kilograms (IQR 26.1, 40.2) in males. There were 10 participants (29%) with suboptimal HGS: 4 (21%) females and 6 (40%) males; only 1 male (6.7%) met the cut-off for low HGS. The median HGS-to-body weight and HGS-to-BMI ratios were 0.50 (IQR 0.40, 0.64) and 1.20 (IQR 1.07, 1.73), respectively. The median 6-minute walk distances were 489 meters (IQR 447, 523) in females and 536 meters (IQR 485, 568) in males. 6 participants (18%) had walking distances < 10% of their predicted values.

The peak heart rate achieved during 6MWT was 52.5% of the maximum predicted heart rate (IQR 46.0, 58.2), and the median metabolic equivalent time (MET) was 3.4 mL/kg/min. The maximum oxygen consumption (VO_2max) was 38.1 mL/kg/min (IQR 35.8, 40.7) in females and 44.0 (IQR 38.1, 46.0) in males. Both were considered "Good" according to Indian norms for healthy adults (Table **2**) [17].

Table 1. Demographic characteristics of study participants.

Variables	Total	Female	Male
Number of participants	34	19	15
Age (years)	23.5 (19.8, 26.0)	24.0 (20.0, 26.0)	22.0 (19.0, 24.0)
Body weight (kg)	55.0 (46.7, 62.8)	53.7 (43.0, 59.8)	59.4 (49.2-66.9)
Height (cm)	160 (150, 165)	153 (148, 159)	165 (160, 169)
Body mass index (kg/m^2)	21.7 (18.6, 24.2)	21.6 (18.6, 24.9)	21.8 (18.5, 24.0)
Waist circumference (cm)	75 (69, 84)	74 (70, 83)	79 (69, 84)
Blood pressure	-	-	-
Systolic	113 (102, 126)	108 (96, 112)	127 (114, 132)
Diastolic	73 (67, 78)	71 (65, 78)	74 (68, 78)
Normal	20 (59%)	15 (79%)	5 (33%)
Elevated	4 (12%)	2 (10%)	2 (13%)
Stage 1 hypertension	10 (29%)	2 (10%)	8 (53%)
Smoking status	-	-	-
Never	20 (67%)	13 (76%)	7 (54%)
Past/ever tried	6 (20%)	3 (18%)	3 (23%)
Current	4 (13%)	1 (6%)	3 (23%)
Drinking status	-	-	-
Never	4 (13%)	3 (18%)	1 (8%)
Occasionally	16 (53%)	9 (53%)	7 (54%)
Monthly/bimonthly	8 (27%)	4 (24%)	4 (31%)
Weekly/biweekly	2 (7%)	1 (6%)	1 (8%)
Exercise habits	-	-	-

(Table 1) contd.....

Variables	Total	Female	Male
Rarely	10 (33%)	6 (35%)	4 (31%)
Occasionally	14 (47%)	6 (35%)	8 (62%)
Weekly/biweekly	6 (20%)	5 (29%)	1 (8%)

Note: Data in median (interquartile range, IQR) or number (%).
kg Kilograms; cm centimeters.

Table 2. Handgrip strength and 6-minute walking distance of adolescents and young adults with perinatal HIV.

Variables	Total (n=34)	Female (n=19)	Male (n=15)
Handgrip strength (kg)	27.3 (22.0, 35.0)	23.8 (20.8, 30.3)	33.6 (26.1, 40.2)
Low handgrip strength	-	-	-
Suboptimal handgrip strength[a]	10 (29%)	4 (21%)	6 (40%)
Low handgrip strength[b]	1 (2.9%)	0	1 (6.7%)
Handgrip strength/body weight ratio	0.50 (0.40, 0.64)	0.46 (0.41, 0.57)	0.62 (0.38, 0.73)
Handgrip strength/body mass index ratio	1.20 (1.02, 1.73)	1.11 (0.96, 1.29)	1.66 (1.19, 1.83)
6-minute walking distance (m)[c]	502 (466, 541)	489 (447, 523)	536 (485, 568)
Resting heart rate (bpm)	89 (83, 100)	86 (80, 94)	90 (82, 103)
Heart rate change (bpm)	12 (6, 19)	12 (8, 18)	9 (6, 24)
% of maximum predicted heart rate	52.5 (45.8, 58.2)	52.5 (48.1, 58.2)	57.5 (45.5, 64.7)
6-minute walking distance < 10% predicted	6/33 (18%)	3/18(17%)	3/15 (20%)
MET (mL/kg/min)	3.4 (3.2, 3.6)	3.4 (3.2, 3.5)	3.6 (3.4, 3.7)
VO_2max (mL/kg/min)	39.0 (37.7, 44.5)	38.1 (35.8, 40.7)	44.0 (38.1, 46.0)

Note: Data in median (interquartile range, IQR) or number (%).
kg kilograms; m meters; bpm beats per minute; MET metabolic equivalent time; mL/kg/min milliliters/kilograms/minute.
[a]Handgrip strength less than mean-1standard deviation per the reference range used.
[b]Handgrip strength less than the mean-2standard deviation per the reference range used.
[c]One female participant did not perform a 6-munite walk test due to physical disability.
Maximum predicted HR = 208- (0.7*age).

4. DISCUSSION

In growing adolescents, in other words, aging young adults who are living with perinatal HIV, metabolic and cardiovascular changes, as well as degenerative diseases, might occur earlier than in the general population [28]. Despite being clinically healthy, which is defined as having no active concurrent illnesses or physical disabilities, the increased risk of non-communicable diseases associated with chronic inflammation was among their long-term health issues of concern. We demonstrated low muscle strength in one-third of YPHIV in this study, while more than 80% had good physical fitness. A study in YPHIV aged 8-14 years in Mozambique reported that 75% of them had low HGS [29]. HGS has been associated with general muscle strength since childhood [30]. Low prevalence of decreased muscle strength in our study might be due to increase age and physical activities during late adolescent years; however, suboptimal strength in some participants might result from living with HIV and other social factors like child-rearing patterns, *i.e.*, YPHIV who were severely ill during childhood, might be overprotected, and limited physical activities by caregivers [31]. According to a study in Brazil, other illnesses like rheumatism or hypertension, as well as psychosocial factors like employment status, were associated with low HGS, while high CD4 and high BMI were protective factors [32]. CD4 data were not available for our participants; however, most were found to have optimal BMI, and some were observed to have elevated blood pressure. Counselling to promote more active lifestyle might partly help, not only to prevent further elevated blood pressure and also to improve muscle strength. Muscle strength varies by sex and body build as males are expected to be stronger than females of the same age, and the peak HGS was observed in the fourth decade of life [33]. This allows time for strengthening exercises to improve muscular fitness in our young participants. Moreover, individuals with lower body weight are expected to have lower muscle strength [34], highlighting the importance of nutritional status. Handgrip strength to BMI ratio was reported as correlated with cardiorespiratory fitness according to a study in Spanish children and adolescents [35]. A Spanish study in young adults (mean age 20.5 years) reported that muscle strength was an independent factor associated with increased cardiometabolic risk [14]. According to a systematic review, muscular fitness in children and adolescents was negatively associated with waist circumference and triglycerides, which were markers of cardiovascular risk [36]. An association between HGS to BMI ratio and metabolic syndrome in older adults was also mentioned [15]. While growing up, muscle strength increases with age to the highest value in the fourth decade of life before declining thereafter [20]. A Japanese study documented that an increased HGS to body weight ratio was associated with a decrease prevalence of metabolic syndrome in middle-aged and elderly people living with HIV [37].

Most participants had good physical fitness from the walking distance testing results. The median MET of 3.4 indicated light work. Good VO_2 max in the study participants indicated that their hearts, lungs, and muscles used oxygen effectively during exercise. As higher VO_2 max levels in adolescence are associated with a favorable metabolic profile and a lower risk of developing cardiovascular diseases later in life [38], age-appropriate physical activities to promote VO_2 max are encouraging to minimize cardiovascular risk associated with their lifelong need for ART. In addition, with increased age, sarcopenia is more prevalent in people living with HIV than in the general population; risk factors included age 30-50 years, being females, and duration of HIV infection, while physical exercise and gait speed were among protective factors [39]. Aerobic fitness would allow them to maintain good shape and attain healthy body composition, including muscle mass, metabolic function, and organ function. Thus, the delayed onset of sarcopenia might be possible.

Although the diagnosis of non-communicable diseases with fulfilled criteria might not always be made until after their second or third decade of life, some adolescents, including a few of the participants, have already been on a lipid-lowering agent concomitant with lifelong ART. Increased pill burden and polypharmacy could affect their sense of well-being and compromise quality of life [40]. As is known, an active lifestyle is a protective factor against metabolic syndrome. The study documented that YPHIV had physical fitness, which could allow them to include exercise in their daily life. There was evidence that supported the effect of exercise on increasing muscle strength and aerobic capacity [41]. One-third of our study participants reported rarely exercising. Thus, physical activities should be promoted in those young people to maximize their peak muscle strength. Handgrip strength and 6MWT are simple assessments that could be performed during a clinic visit. The results could be used to encourage age-appropriate exercise. The study limitations included, first, a small sample size and the possibility of selection bias, as we recruited participants who were active and willing to participate. They might perform better than YPHIV, which did not show up or had a suboptimal social functionSecond, HIV-related variables and other clinical data were not accessible in the study participants' medical records, as the study was conducted outside the healthcare setting. Third, healthy young people without HIV from similar social and environmental contexts were not included for comparison. A future study including a larger cohort of YPHIV and a control population of the same age range, either with non-perinatal HIV or without HIV, would be beneficial.

The strength of the study lies in representing a cohort of young people with perinatal HIV infection in Thailand, one of the first countries to start ART in infants and young children over the past few decades. This group has been living with HIV since birth, surviving with ART, and progressing toward middle age. Despite limited generalizability, the results are expected to help raise awareness among YPHIV and healthcare providers regarding the importance of physical exercise in minimizing cardiovascular risk and other metabolic complications.

5. STUDY LIMITATIONS

As we selected active, willing participants, the study had a limited sample size and a risk of selection bias. They may outperform YPHIV, who did not show up or had poor social function. Second, as the study was conducted outside of healthcare, we did not have access to HIV-related factors or other clinical data in the participants' medical records. Third, youth with non-perinatal HIV, or without HIV in similar social and environmental situations, were not included for comparison.

CONCLUSION

Despite being clinically healthy and having good physical fitness, nearly one-third of YPHIV had suboptimal muscle strength for their age and gender. Physical activities and muscle-strengthening exercises should be encouraged to reduce metabolic risk, improve muscle strength to achieve peak strength, and minimize the risk of sarcopenia later in adult life.

AUTHORS' CONTRIBUTIONS

The authors confirm contribution to the paper as follows: L.A. and C.K.: Designed the study; R.T.K.: Recruited participants and obtained written informed consent; R.T.K., S.U.C. and S.O.K.: Performed data collection; L.A. and C.K.: Did the data analysis and interpretation; L.A.: Prepared the first draft of the manuscript. All authors reviewed, edited, and approved the final manuscript.

LIST OF ABBREVIATIONS

HGS	=	Handgrip strength
MET	=	Metabolic equivalent time
BMI	=	Body mass index

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Institutional Review Board at the Research Institute for Health Sciences, Chiang Mai University, Thailand (Certificate approval number 80/2024).

HUMAN AND ANIMAL RIGHTS

All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

Before enrollment, participants provided written informed consent; for those under 20 years of age, consent was obtained from the caregiver and the participant, respectively.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available in the Zenodo Repository at https://doi.org/10.5281/zenodo.19329679.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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