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Physical functioning in adolescents with perinatal HIV

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ABSTRACT

Perinatal HIV impacts on growth and development in childhood, with physical impairments such as growth limitations, decreased physical activity, reduced exercise tolerance and cardiopulmonary dysfunction continuing into adolescence. There is limited data on other physical functioning domains in perinatally HIV-infected adolescents (PHIVA) thus the aim of this study was to establish the physical sequelae of perinatal HIV in adolescents. This South African cross-sectional study compared PHIVA with HIV-negative adolescents, assessing anthropometry, muscle strength, endurance and motor performance. All ethical considerations were adhered to. The study included 147 PHIVA and 102 HIV-negative adolescents, aged 10–16 years. The majority (87.1%) of PHIVA were virally suppressed however, they still showed significant deficits in height ($p < 0.001$), weight ($p < 0.001$) and BMI ($p = 0.004$). Both groups performed poorly in muscle strength and endurance but did not differ significantly. In motor performance, the PHIVA scored significantly lower for manual dexterity and balance, with significantly more PHIVA with motor difficulty. A regression analysis showed that viral suppression predicted muscle strength ($p = 0.032$) and age positively predicted endurance ($p = 0.044$) and negatively predicated aiming and catching ($p = 0.009$). In conclusion, PHIVA face growth deficits and challenges with motor performance, especially with manual dexterity and balance.

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HIV; physical functioning; muscle strength; endurance; growth; adolescence

Introduction

Despite great strides in HIV-related healthcare the disease continues to be a global burden, both in adult and childhood populations (Pandey & Galvani, 2019). In 2019 there were an estimated 1.7 million adolescents living with HIV (UNICEF, 2020a) and as access to antiretroviral therapy (ART) continues to expand so this population increases, shifting paediatric HIV management to that of a chronic disease (Fairlie et al., 2014; Sohn & Hazra, 2013).

Due to the nature of the virus itself, as well as the toxicity of drug therapy [with either highly active ART or combination ART (Menéndez-Arias & Delgado, 2022)], children and adolescents are particularly vulnerable to adverse effects as they go through critical periods of growth and development (Flynn & Abrams, 2019). Research is showing that perinatally HIV-infected adolescents (PHIVA) face neurocognitive dysfunction and mental health issues (Laughton et al., 2013; Lowenthal et al., 2014; Smith & Wilkins, 2015; Willen et al., 2017), as well as physical sequelae such as growth impairment (Arbeitman et al., 2014; Jesson et al., 2019), decreased physical activity (Martins et al., 2017) reduced exercise tolerance (Ferrand et al., 2012) and impaired cardiopulmonary health (Miller et al., 2013). Adolescents themselves have expressed that they experience physical difficulties, with poor endurance, pain and fatigue being the most common complaints (Comley-White et al., 2021).

In 2004, South Africa began with ART rollout (Evans, 2013) and initially the criteria for ART initiation was the presence of an AIDS-defining condition or a CD4 count of less than 200cell/mm^3 (Osler et al., 2018), thus leaving many people (children and adults) with HIV as not eligible for ART initiation for long periods of time. As early initiation of ART and healthcare access improved, so HIV has shifted to a chronic illness, creating a growing population of children with perinatal HIV aging into adolescence in South Africa (Anderson et al., 2020; Fairlie et al., 2014).

With the increasing number of PHIVA there is progressively more research that is becoming available on the long-term effects of perinatal HIV, however, there are still many gaps in the clinical knowledge and a paucity of healthcare options. While it is well-established that children with perinatal HIV are negatively impacted in growth and development (Strehlau et al., 2019; Whitehead et al., 2014) there are areas of concern in PHIVA that need further investigation. Thus the aim of this study was to establish the physical sequelae of

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perinatal HIV in adolescents. By determining this, the authors wish to create a background for screening and early intervention for this distinctive population, in turn leading to improved quality of life and health outcomes.

Materials and methods

Design

This study used a cross-sectional design, comparing data between PHIVA and a comparison group of HIV-uninfected adolescents, forming one of the phases of a larger study used for the development of a model of care for PHIVA. Further details on the methodology of this larger study have been published elsewhere (Comley-White et al., 2019).

Study site and participant selection

The study site was a large, urban HIV clinic and research unit in Johannesburg, South Africa. Data was collected from a longitudinal cohort of PHIVA that were followed through childhood as part of the Childhood HAART Alterations in Normal Growth, Genes and AGing Evaluation Study (CHANGES). The HIV-uninfected participants were accessed via a database that forms part of the CHANGES study. These adolescents are HIV negative family members, friends or community members of the PHIVA cohort, and as such are from a similar sociodemographic background as the PHIVA participants.

Adolescence is defined as 10–19 years (UNICEF, 2016; World Health Organization, 2014) and all of the CHANGES children were in the early and middle phases of adolescence, with a cut-off age of 16 years. Participants were excluded if (1) they had any cognitive/physical impairments that prevented them from taking part in the assessment process or that were not related to HIV (for example, a traumatic brain injury); (2) if the mode of transmission for the PHIVA group was not vertically acquired.

Procedure and instrumentation

In 2019 (January to October) suitable adolescents were identified from the clinic's data base and contacted telephonically with information about the study and an invitation to participate. Upon arrival at the study site, the clinic counsellor obtained participant assent and parental consent. Clinical and demographic data were collected from the participants' files and the following variables were assessed by the principal investigator and a research assistant (both of whom were physiotherapists): height, weight, muscle strength, endurance and motor performance. The standing broad jump and the shuttle run test were used to assess muscle strength and endurance, respectively, and the Movement Assessment Battery for Children- Second Edition (MABC-2) evaluated motor performance.

Ethical considerations

The Human Research Ethics Committee (Medical) of the University of the Witwatersrand granted ethical clearance (M180226) and all ethical requirements were adhered to. Potential participants were invited to the study telephonically and/or on the day of their clinic visit. Informed consent and assent were obtained and all data were kept confidential.

Data analysis

The demographic data were described with frequencies, means and standard deviations. Height-for-age z-scores (HAZ) and body mass index (BMI)-for-age z-scores (BAZ) were calculated using World Health Organization reference data (de Onis, 2007; World Health Organization, 2021). Weight-for-age reference data are not available for children over 10 years old since pubertal growth spurts can distort the relativity of height to body mass (World Health Organization, 2021). Stunted was defined as height-for-age < -2 standard deviations (SD) and wasted was defined as BMI-for-age < -2SD (World Health Organization, 2008).

Normality tests were run for all variables and data were normally distributed, with exception of the final standard score of the MABC-2. To compare the two groups, independent sample t tests were used except for the non-normative data that had Mann–Whitney U tests applied. Statistical significance was set at $p < 0.05$ (Vexler & Hutson, 2018). Multivariate linear regression analyses were run to analyse the influence of the clinical variables on the outcome measures.

Data for the MABC-2 were analysed to show the standard score means and standard deviations for each component, as well as the frequency and percentages of the participants whose standard score results placed them in the red, amber or green zones. These zones are indicative of significant motor difficulty, at risk of motor difficulty and no motor difficulty, respectively.

At the time of data cleaning and analysis it was observed that there were sporadic data collection forms with information incomplete. The sample size for each of these outcome measures was adjusted on analysis and is reflected in the tables of results.

Results

Demographic and clinical information

The study included 249 participants, of which 59% (n = 147) were PHIVA and 41% (n = 102) were the HIV-negative comparison group. The mean age for the two groups was the same [12 (SD ± 1–2) years], with the year of birth ranging from 2003 to 2009. Table 1 presents the demographic information for the study population.

Clinical data for the PHIVA group is presented in Table 2. The mean age at which the participants' HIV diagnosis was made was 4.7 months (SD ± 5.9) and the mean age at ART initiation was 8.5 months (SD ± 6.6 months). At the time of assessment, the group had a mean CD4% of 38.3 (SD ± 7.1) and the majority (87.1%) of the participants had viral loads <200 copies/ml.

Anthropometry

The PHIVA group presented with statistically significant lower weight ($p < 0.001$), height ($p < 0.001$) and BMI ($p = 0.004$) when compared to the HIV negative adolescents. Although the mean HAZ and BAZ results for each group were within acceptable ranges (i.e., > −2SD), the PHIVA group scored lower for both variables ($p = 0.246$ and $p = 0.236$, respectively) and significantly more PHIVA were stunted and wasted compared to the HIV negative adolescents (23.1% vs. 2.9% and 6.8% vs. 4.9% respectively; $p = 0.036$). Further data on the anthropometric results are presented in Table 3.

Muscle strength and endurance

The two groups did not differ significantly in their muscle strength or endurance. Table 4 presents the results of the muscle strength and endurance assessments.

Motor performance

On the MABC-2 the PHIVA performed worse than the HIV-negative group, however the difference in the final standard score was not statistically significant (p = 0.144). Despite this, there are important differences on the subscales. The PHIVA group performed significantly worse than the comparison group for manual dexterity ($p = 0.021$) and balance ($p = 0.020$) standard score means. Furthermore, an analysis of the frequencies of participants scoring in the red (i.e., significant motor difficulty), amber (i.e., at risk of motor difficulty) and green (i.e., no motor difficulty) zones showed that significantly more PHIVA than HIV-negative participants were in the red zone for the final MABC-2 scores (13.2% vs. 4.1%, $p = 0.054$). Although not reaching statistical significance, it is noteworthy that there were more PHIVA than HIV negative participants who scored in the red zones for manual dexterity (15.8% vs. 11.1%, $p = 0.064$), and balance (6.3% vs 4.0%, $p = 0.082$); and in the amber zones for manual dexterity (9.6% vs. 3.0%, $p = 0.064$), aiming and catching (6.8% vs. 3.0%, $p = 0.306$) and balance (4.2% vs. 0.0%, $p = 0.082$), Table 5 presents further results on the participants' motor performance.

Clinical predictors

A multivariate linear regression model was used to analyse the influence of the clinical variables of age, sex, height, weight, BMI, viral suppression, current CD4%, age of HIV diagnosis and age of ART initiation on the outcome variables, namely muscle strength, endurance and motor performance. Once the assumptions of multivariate normality, linearity, freedom from extreme values and multi-collinearity were cleared, the regression analysis was performed.

The regression model as a whole (i.e., a combination of all of the clinical variables) was significant for muscle strength ($R^2 = 0.193$; $p = 0.14$) and endurance ($R^2 = 0.213$; $p = 0.006$) however the model was not significant for predicting motor performance ($p = 0.886$). Table 6 presents the results of investigating each clinical variable individually to establish the independent variables prediction of the dependent variables.

Table 1. Demographic data of the study population (n = 249).

	HIV negative adolescents n = 102	HIV positive adolescents n = 147	P value
Male, n (%)	60 (58.8)	73 (49.7)	0.154
Female, n (%)	42 (41.2)	74 (50.3)	0.154
Age in years, mean (SD)	12 (±1)	12 (±2)	0.91
Minimum age	10 years 0 months	10 years 0 months	-
Maximum age	16 years 11 months	15 years 12 months	-

Table 2. Clinical data of the HIV positive participants.

Clinical data	Values
Mean age at HIV diagnosis, months (n = 107)	4.7 (SD ± 5.9)
Mean age at ART initiation, months (n = 147)	8.5 (SD ± 6.6)
Mean CD4 count, cells/mm^3 (n = 147)	1011.6 (SD ± 305.7)
Mean CD4 percentage (n = 145)	38.3 (SD ± 7.1)
Number of participants with viral load < 200 copies/ml (n = 147)	128 (87.1%)
Number of participants with viral load > 200 copies/ml	19 (12.9%)

Table 3. Anthropometric results for the study population (n = 249).

	HIV negative adolescents n = 102	HIV positive adolescents n = 147	P value
Weight in kilograms, mean (SD)	42.8 (±13.2)	36.8 (±10.2)	**<0.001**
Height in metres, mean (SD)	1.5 (±0.1)	1.4 (±0.1)	**<0.001**
BMI, mean (SD)	19.3 (±4.3)	17.9 (±3.2)	**0.004**
HAZ, mean (SD)	−0.3 (±1.0)	−1.1 (±1.1)	0.246
BAZ, mean (SD)	0.3 (±1.4)	−0.3 (±1.2)	0.236
Stunted, n (%)	3 (2.9)	34 (23.1)	**0.036**
Wasted, n (%)	5 (4.9)	10 (6.8)	**0.036**

HAZ = height-for-age z-score; BMI = body mass index: BAZ = BMI-for-age z-score; stunted = <−2SD; wasted = <−2SD.

For the individual clinical variables, only viral suppression statistically significantly predicted muscle strength ($p = 0.032$) while age significantly predicted the endurance ($p = 0.044$). Finally, although the model was not a good fit for motor performance, age was the only variable that was statistically significant in predicting aiming and catching ($p = 0.009$), however it was a negative prediction (while the former two were positive predictions).

Discussion

This study aimed to establish the physical sequelae of perinatal HIV in adolescents through a cross-sectional analysis of PHIVA and an HIV-negative comparison group. The results of this study shows that there are significant physical sequelae that PHIVA face with regards to stunting, wasting and motor performance.

Despite the PHIVA population of this study having early diagnosis (mean age: 4.7 months, SD ± 5.9), early ART initiation (mean age: 8.5 months, SD ± 6.6 months) and majority viral suppression (87.1%), they still presented with multiple physical challenges. This is a concerning finding, especially since this sample of PHIVA were well-managed, with regular follow-up appointments and access to health care via a large, urban HIV research unit. With many PHIVA not accessing regular health care in sub-Saharan Africa (Eba & Lim, 2017; Sam-Agudu et al., 2016) [where more than 88% of children and adolescents with HIV live (UNICEF, 2020b)], these sequelae are potentially even more

Table 4. Muscle strength and endurance results for the study population (n = 249).

	HIV negative adolescents n = 102	HIV positive adolescents n = 145 (2 incomplete records)	P value
Muscle strength: standing broad jump in metres, mean (SD)	120.3 (±21.5)	121.5 (±25.5)	0.716
Endurance: shuttle run test in metres, mean (SD)	277.0 (±132.1)	298.3 (±137.7)	0.225

Table 5. Motor performance results for the study population (n = 249).

	HIV negative adolescents n = 102	HIV positive adolescents n = 147	P value
MABC-2: manual dexterity			
Complete records, n (%)	99 (97.1)	146 (99.3)	-
Standard score, mean (SD)	9.0 (±2.6)	8.2 (±2.7)	**0.021**
Red zone, n (%)	11 (11.1)	23 (15.8)	0.064
Amber zone, n (%)	3 (3.0)	14 (9.6)	
Green zone, n (%)	85 (85.9)	109 (74.7)	
MABC-2: aiming and catching			
Complete records, n (%)	99 (97.1)	146 (99.3)	–
Standard score, mean (SD)	10.2 (±3.7)	10.0 ± (3.3)	0.573
Red zone, n (%)	14 (14.1)	15 (10.3)	0.306
Amber zone, n (%)	3 (3.0)	10 (6.8)	
Green zone, n (%)	82 (82.8)	121 (82.9)	
MABC-2: balance			
Complete records, n (%)	100 (98.0)	144 (98.0)	–
Standard score, mean (SD)	11.87 (±2.7)	10.95 (±3.2)	**0.020**
Red zone, n (%)	4 (4.0)	9 (6.3)	0.082
Amber zone, n (%)	0 (0.0)	6 (4.2)	
Green zone, n (%)	96 (96.0)	129 (89.6)	
MABC-2: total			
Complete records, n (%)	98 (96.1)	144 (98.0)	–
Standard score, mean (SD)	10.3 (±3.0)	9.95 (±6.7)	0.144
Red zone, n (%)	4 (4.1)	19 (13.2)	**0.054**
Amber zone, n (%)	5 (5.1)	5 (3.5)	
Green zone, n (%)	89 (90.8)	120 (83.3)	

MABC-2: Movement Assessment Battery for Children- Second Edition.

Table 6. Regression analysis results reaching statistical significance for individual clinical variables.

Dependent variable	Independent variable	Unstandardized B coefficient	T score	P value
Muscle strength	Viral suppression	13.312	2.176	0.032
Endurance	Age	28.239	2.042	0.044
Aiming and catching	Age	−0.892	−2.667	0.009

prevalent. A review of long-term virologic outcomes in PHIVA living in low- and middle-income countries found that the median age of ART initiation was 4–9 years and that viral suppression ranged from 53% to 68%, and specifically in South Africa, it was 5–11 years and 69% to 81%, respectively (Anderson et al., 2020). Anderson et al.'s (2020) values are substantially poorer than the viral suppression frequency (87.1%) and mean age of ART initiation (8.5 months, SD ± 6.6 months) for this study's population thus indicating the potentially greater prevalence of physical sequelae in other PHIVA. This highlights the necessity of regular healthcare monitoring and access to early diagnosis and ART initiation.

Anthropometry

The PHIVA group had significantly lower height ($p < 0.001$), weight ($p < 0.001$) and BMI ($p = 0.004$) compared to the HIV-negative adolescents, and they were significantly more stunted ($p = 0.036$) and wasted ($p = 0.036$). Perinatal HIV inhibits growth and development in children (Cruz & Cardoso, 2015; Williams & Jesson, 2018) and Jesson et al. (2019) found that a lower CD4 count and later ART initiation were associated with poorer growth in PHIVA. This study highlights that despite early diagnosis, ART initiation and regular follow-up growth deficits continue into adolescence.

Stunting in childhood impacts on pubertal development and it has been well established that pubertal delay occurs in PHIVA (Bellavia et al., 2017; Cruz & Cardoso, 2015; Ferrand et al., 2012; Iloh et al., 2017; Williams & Jesson, 2018). Stunting also has a long-term impact on cognition, academic and economic performance, and maternal reproductive function (Crookston et al., 2011; Dewey & Begum, 2011). Wasting is associated with chronic infections, inflammation and higher levels of morbidity and mortality (Harding et al., 2018). These deleterious effects of stunting and wasting are an indication of the need for regular monitoring of PHIVA in terms of growth, pubertal development, academic performance and cognition.

Muscle strength and endurance

Although there were no differences between the two groups for muscle strength and endurance both performed below the expected norms for their ages (Hardy et al., 2018; Saint-Maurice et al., 2015; Tomkinson et al., 2017). This could be due to the general decreased levels of physical activity that this group of children may be experiencing. One needs to consider that this population is based in a low socio-economic environment and general access to school sport, extramural activities and club sports would potentially be limited.

Many studies include children living with HIV (CLHIV) who are less than 10 years old, i.e., not PHIVA, and present the data of younger children and adolescents together. These studies provide valuable information about the sequelae of perinatal HIV, affecting both younger children and adolescents. Research in CLHIV has shown mixed results on muscle strength, power and endurance. Potterton et al. (2022) and Ramos et al. (2012) found no differences in the muscle strength of CLHIV and HIV-negative participants, however in Ramos et al.'s (2012) study anaerobic power was significantly lower in CLHIV and Somarriba et al. (2013) found significantly decreased lower extremity muscle strength in their population of 7–20 year old participants living with HIV. Although small, deficits in muscle power have been found in another study looking at perinatal HIV in children aged 8–25 years (Macdonald et al., 2017) but further research in this area is lacking.

In our study, although they did not differ significantly, both groups of adolescents performed overall poorly in endurance. Chisati and Vasseljen (2015) assessed aerobic endurance in Malawian young adults with HIV, and found that they had significantly lower endurance compared to the HIV-negative group. Similarly, an assessment of Malawian children and adolescents with perinatal HIV (aged 5–18 years) using the six minute walk test (6MWT) showed that the HIV-positive group walked significantly shorter distances than the HIV-negative comparison group ($p = 0.015$) (Sims Sanyahumbi et al., 2017). Other studies present contrasting findings: a South African cohort of well-managed CLHIV with early ART initiation did not differ significantly from their HIV-negative peers on the 6MWT (Potterton et al., 2022), nor did another South African cohort of PHIVA compared to an age-matched HIV-negative group (Githinji et al., 2019). It should be noted, however, that the 6MWT is an assessment of submaximal endurance and thus is not necessarily sensitive enough to detect mild cardiopulmonary deficits (Githinji et al., 2019).

Other studies have used VO_{2peak} as an outcome measure showing decreased endurance in HIV-positive adolescents (Cade et al., 2002; de Lima et al., 2017; Keyser et al., 2000; Somarriba et al., 2013) and Githinji et al. (2017) assessed lung function in 515 South African PHIVA and found significant lung dysfunction compared to HIV-negative adolescents, thus indicating significant functional aerobic impairment and cardiorespiratory insufficiency for this population.

Aerobic and cardiorespiratory impairments are part of the multifactorial nature of decreased endurance. In addition to the potential low levels of physical activity found in PHIVA, impairments such as moderate to severe dyspnoea have been reported in 34.4% of a PHIVA population (Mwalukomo et al., 2016).

Motor performance

The PHIVA group did poorly in motor performance, with significantly lower performance in the standard score for manual dexterity (0.021) and balance (p = 0.020), and with significantly more PHIVA than HIV-negative adolescents scoring in the red and amber zones for the total MABC-2 score (p = 0.054), thus highlighting the risk of poor motor performance in PHIVA.

Studies have shown a decline in motor function over time in adults living with HIV (Elicer et al., 2018) and that CLHIV face developmental delay (Baillieu & Potterton, 2008; Ruel et al., 2012; Strehlau et al., 2019) but research is lacking in PHIVA. Willen et al. (2017) investigated neurocognitive outcomes in perinatally infected young adults (aged 18–24 years) and found executive dysfunction, with motor speed being significantly worse in the perinatally infected participants compared to a HIV-negative comparison group. Similarly, Horvath et al. (2018) found accelerated epigenetic aging in a group of South African PHIVA which correlated with poorer cognitive functioning, including processing speed. Neurocognitive dysfunction can be caused by delayed cortical maturation and atrophy of the motor cortex that occurs in PHIVA (Yu et al., 2019).

Poor manual dexterity has negative implications for a child's school performance, with handwriting and activities of daily living, such as playing, being affected (Gaul & Issartel, 2016; Mathisen, 2016). Children and adolescents with perinatal HIV already face neurocognitive dysfunction and poor academic performance (Garvie et al., 2014; Phillips et al., 2022; van Opstal et al., 2021) and thus decreased manual dexterity can further disadvantage the adolescent academically.

Balance is important in all daily functioning activities such as mobility, fall prevention and quality of life (Kovács et al., 2013; Schwartz et al., 2012; Surgent et al., 2019). Balance in younger CLHIV and PHIVA has been found to be negatively affected (da Silva Pontes et al., 2019; Debeaudrap et al., 2018; Medeiros et al., 2022).

Clinical predictors

Although the multivariate regression analysis did not reveal multiple significant predictive factors, it is still of value to consider that the overall clinical picture of PHIVA can be used to predict their endurance and muscle strength, more specifically in terms of age (B = 28.239) and viral suppression (B = 13.312), respectively. Further studies involving these variables could be used to create a predictive model for physical functioning in PHIVA, especially since such a model is not currently available.

Viral load has an inverse relation to physical activity (Bopp et al., 2004) and physical functioning (Nieves-Lugo et al., 2017), resulting in a poorer health-related quality of life in people with HIV (Call et al., 2000), thus it is fitting that this study found viral suppression to be predictive of muscle strength, a component of physical health. Another study in South Africa found that BMI and Tanner staging were positively associated with muscle strength in CLHIV (Potterton et al., 2021) however our study did not assess Tanner staging nor did the authors find BMI to be a predictive factor. This may be because the participants in the study by Potterton et al. (2021) were younger (age 5–11 years) than the current study's participants and thus the results cannot be a direct comparison.

This study found age to have a negative prediction on the aiming and catching component of the MABC-2 (B = −0.892). Since PHIVA show smaller increases in physical activity levels with age when compared to HIV-negative peers (Dirajlal-Fargo et al., 2021) it can be expected that with age the skill of aiming and catching would decrease, i.e., as their physical activity levels are lower.

Limitations and recommendations

The participants of this study were accessed from only one clinical site, thus the results are not generalisable to all PHIVA. Furthermore, the HIV-negative participants were mostly siblings of the PHIVA participants and thus may have been HIV-exposed uninfected (HEU) adolescents, however this status was not established during data collection. Studies are showing that many HEU children still face growth and neurodevelopmental sequelae (Wedderburn et al., 2019) and thus the negative outcomes of this study's PHIVA may be even greater when compared to HIV-unexposed uninfected (HUU) adolescents. Future recommendations for research would be to replicate this study using HUU adolescents as a comparative group and to investigate the same outcome measures in PHIVA who are not as well managed medically as this group.

An additional recommendation is for research on endurance in PHIVA using the shuttle run test. To the best of the authors' knowledge, no other studies

have used the shuttle run test to assess endurance in PHIVA and future research would be beneficial, both in the PHIVA population and the general South African adolescent population.

Conclusion

This study aimed to establish the physical sequelae of perinatal HIV in adolescents. The results showed that PHIVA have significant sequelae in height, weight and motor performance. It is of particular concern that these deficits are apparent in PHIVA who are mostly virally suppressed and well managed medically, highlighting the clinical concern for PHIVA across the rest of the globe who do not necessarily have sufficient access to health care and regular monitoring. A population-specific model of care and regular screening of physical sequelae in PHIVA is recommended for clinical practice to try and mitigate these deficits.

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Ethics approval

Approval was obtained from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand (M180226). The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent

All caregivers and children signed consent and assent respectively.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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