Effects of Moderate Acute Malnutrition Treatment and HIV-Exposure on Body Composition among Children Under Five Years in Sub-Saharan Africa: A systematic review

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Abstract

BACKGROUND

Malnutrition poses a global threat to childhood growth and survival. Coupled with HIV exposure and infection, under-nutrition risk is greatly increased. Infection with HIV results in Acquired Immune Deficiency Syndrome which increases the body's nutrient requirements and may significantly affect the body composition parameters. This study aimed to review data from published articles to identify the changes in body composition among children under five in sub-Saharan Africa as a result of Moderate Acute Malnutrition (MAM) and HIV exposure

MATERIALS AND METHODS

We conducted a systematic review of published articles on body composition, moderate acute malnutrition treatment and HIV exposure among children under five years. Data was searched from PubMed, Ovid-MedLine, Google Scholar, Cochrane Central Register of Controlled Trials and EMBASE. The review was done as per Cochrane reviews and Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA). The articles were then screened for suitability of inclusion and analysis.

RESULTS

A total of 1,505 records were identified; 520 articles from PubMed, 535 from Medline and 430 from EMBASE. On the first screening step, 755 duplicate records were removed. Screening the articles by abstract and title led to the elimination of 717 records. Further, 88 records were excluded due to a lack of full-text articles, not related to the topic, no prospective studies and the wrong age group (above five years). We finally ended up with 9 articles that were included for review.

CONCLUSIONS

There is an interrelationship between MAM treatment, HIV Exposure and body composition. Treatment of MAM using standard ready-to-use supplemental foods and locally produced specialized nutritious formulas improves the body composition parameters of children under five years. HIV-exposed infected children exhibit poorer body composition parameters than HIV-exposed uninfected and HIV-unexposed uninfected children.

Keywords: *Body Composition, Moderate Acute Malnutrition, HIV Exposure, Sub-Saharan Africa*

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Introduction

In most developing countries across the world, childhood malnutrition (under-nutrition) is a major public health challenge (1–3) and contributes to over 50% of the more than 10 million deaths experienced among children under five years annually (4,5). Globally, 45% of the deaths among children below the age of five years are occasioned by nutrition-related factors (6). In 2021, Africa experienced 74 deaths per 1,000 live births of children under five years compared to the global prevalence of 38 deaths per 1,000 live births in the same period due to malnutrition and other related factors (7). The prevalence of malnutrition varies from one nation to another with countries in Sub-Saharan Africa (SSA) being severely affected (8). Globally, 149 million children under 5 years of age are stunted, 49.5 million are wasted and 40.1 million are overweight (9). The prevalence of stunting in SSA (30.7%) is higher than the global prevalence (22%) and wasting stands at 6.0% (9). Besides mortality, malnutrition has adverse effects on the body composition of children under five years as they experience decreased muscle mass, free fat mass (FFM) and fat mass (FM) (10,11). Furthermore, children infected with HIV experience reduced food intake, increased risk of opportunistic infections, malabsorption of nutrients, and impaired metabolism leading to weight loss and growth impairment (12).

In the majority of countries across the world, supplementation of children with Ready to Use Supplemental Food (RUSF) remains the standard guideline for the treatment of uncomplicated Moderate Acute Malnutrition (MAM) (13). However, the emergence of improved formulations of cereal, cereal–legume blends and lipid-based nutrient supplements (LNSs) have been claimed as superior in MAM treatment due to their enhanced nutrient composition, low cost of production and ease of preparation (14,15). A debate still exists on whether the specialized nutrition formulas (SNFs) affect body composition and if that possesses consequences for sustainability towards MAM recovery in the short term as well as health risks and disease in the long term. Additionally, guidelines attached to a proportional or absolute gain of FM and FFM among children who are in MAM recovery stages and HIV exposure are limited (16).

The interrelation between malnutrition and HIV infection has been studied and adequately documented (17,18). However, few studies have looked at body composition changes in HIV-exposed young children during treatment for MAM and given the grave concern for both short-term and long-term implications attached to childhood MAM especially among HIV-exposed under five children. Thus, the objective of this study was to review the literature on the body composition changes as a result of MAM treatment and HIV exposure among infants and young children under five years old from Sub-Saharan Africa. The study generates credible information from published sources that contribute to the scanty literature on body composition changes among children under MAM treatment.

Materials and Methods

Search strategy and information sources

The study adopted a systematic review by Cochrane Reviews using the CABI abstract database via Ovid and Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA). Data was independently extracted from published sources, using content analysis and structured documentary guides. The information sources and searches were collected from PubMed, Ovid-MedLine, Google Scholar, Cochrane Central Register of Controlled Trials and EMBASE.

Boolean operators were used to search the relevant key terms using string commands. These commands include truncations, parentheses, and phrases. The keywords included "*body composition" AND "Moderate Acute Malnutrition" OR "Malnutrition," AND "young children" OR "children aged 18*

months to 5 years" OR "infants" AND "HIV-exposed children" AND "Treatment for MAM." The Patient/Population, Intervention, Comparison and Outcomes (PICO) framework (19) presented in Table 1 was used in the articles search. The paper searched published peer-reviewed articles and a total of 1505 search records were obtained.

Bias and quality assessment

The abstract and study title were imported into Mendeley systematic review software to conduct risk bias assessment for potential confounding and assessed for eligibility. Quality was assessed using the Assessment of multiple systematic reviews (AMSTAR) (20).

Table 1:
PICO framework for articles search strategy

Population	Intervention	Comparison	Outcome
Children with Moderate Acute Malnutrition (MAM	Treatment for MAM	HIV-exposed infected children HIV-exposed uninfected children HIV-unexposed uninfected children	Changes in body composition parameters • % Fat mass • % Free fat mass • Muscle mass • Weight gain/loss • Basal metabolic rate

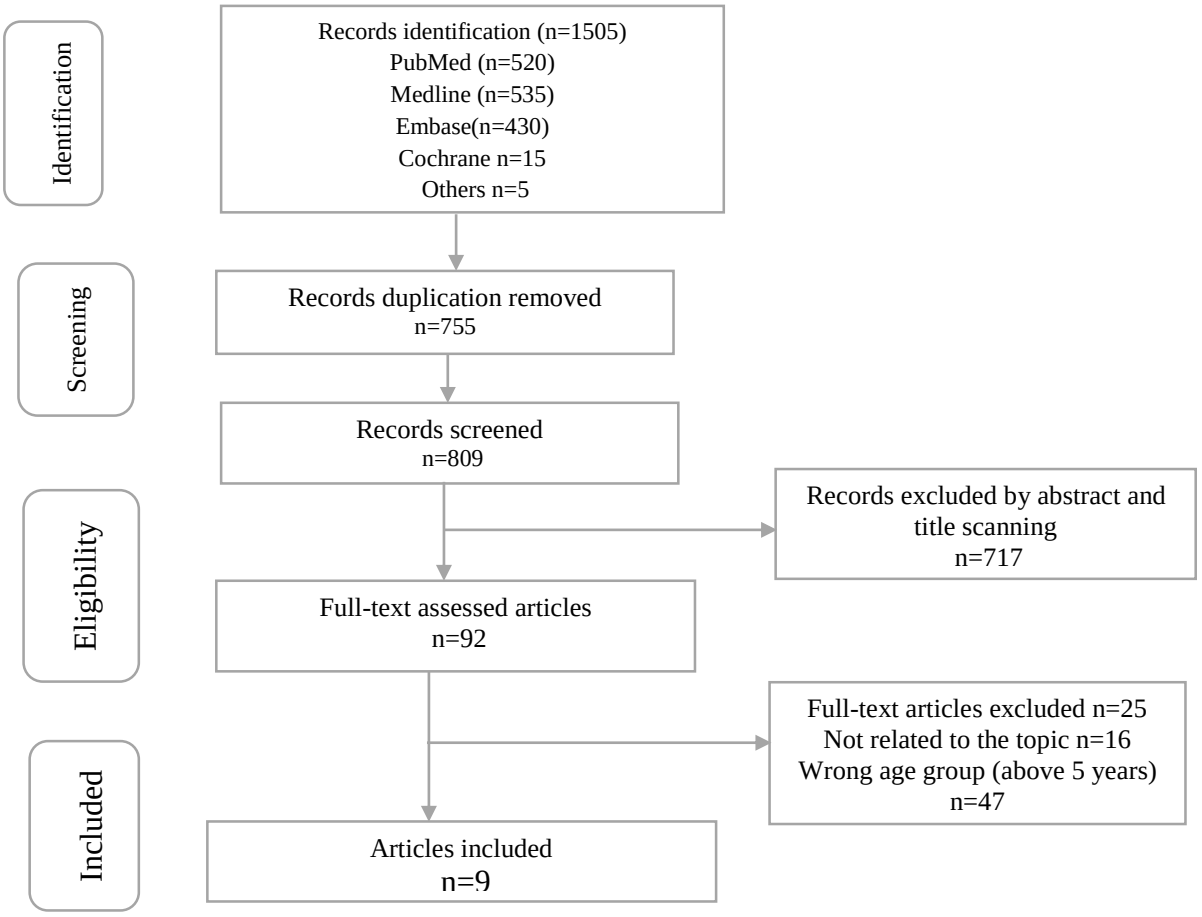

Figure 1:
PRISMA flow chart

Inclusion and exclusion criteria

Inclusion and exclusion criteria were independently applied to full-text reports and screened using Mendeley reference manager and records duplicate of 755 were excluded. Full-text evaluation of 92 articles was carried out of which 88 articles were excluded leaving nine (9) articles eligible for review and analysis as per the PRISMA chart in Figure 1. The inclusion criteria also factored in studies that were reporting on the management/treatment of MAM, HIV exposure status of children (HIV Exposed Infected (HEI), HIV Exposed Uninfected (HEU) and HIV Unexposed Uninfected (HUU)) and body composition changes. Studies conducted outside Sub-Saharan Africa and among children above 5 years were excluded from the review. Table 2 presents a summary of articles used in this study.

Results and Discussion

General characteristics of the reviewed articles

In this review, out of the nine studies identified for inclusion, (33.3%, n=3) of the studies were published in 2019 followed by 2017 (22.2%, n=2) with two (22.2%) of the studies conducted in Kenya. By the study design, 44.4%, n=4 were cohort studies and 33.3%, n=3 were cluster randomized controlled trials. Generally, the reviewed articles were from East and West Africa with no articles from Central Africa which is part of SSA. The key themes the authors reviewed were; treatment/management of moderate acute malnutrition, HIV exposure status (HEI, HEU, HUU) and body composition of children under five years.

Moderate Acute Malnutrition (MAM) treatment and body composition of children under 5 years

Moderate Acute Malnutrition (MAM) is characterized by having a weight-for-height (stature) Z score (WHZ) in the range of −3SD to −2 SD (29). Most children under 5 years in Sub-Saharan Africa are at an extended risk of MAM and this adversely affects their body composition (30). Konyole *et al*., (31) attributed having low Weight for Length Z-scores (WLZ) and Length for Age Z-scores (LAZ) with reduced lean tissue mass. Similarly, Benefice *et al*., (32) found stunted children aged 6–18 months had lower BMI, subcutaneous arm girth and skinfold thickness than their non-stunted children of the same age in Senegal.

***Table 3*:**
Summary distribution of the reviewed studies

Variables	Characteristics	n	%
By the year of publication	2016	1	11.1
	2017	2	22.2
	2019	3	33.3
	2020	1	11.1
	2021	1	11.1
	2023	1	11.1
By country	Kenya	2	22.2
	Rwanda	1	11.1
	Zambia	1	11.1
	Nigeria	1	11.1
	Mali	1	11.1
	Botswana	1	11.1
	Sierra Leonne	1	11.1
	Multicountry	1	11.1
By study design	Cohort study	4	44.4
	Cluster randomized trial	3	33.3
	Retrospective chart review	1	11.1
	Cross-sectional	1	11.1

A lower free fat mass index (FFMI) was reported among children 6-59 months with both severe stunting and wasting (33). The treatment of MAM with the standard RUSF has shown high effectiveness and recovery rates (34). However, it is challenged by the high cost of purchasing the supplements and inadequate supplies since most countries in SSA depend on donations of the supplements (35). This has enhanced the innovation of alternative options using locally available ingredients to formulate specialized nutrition formulas and foods for the management of uncomplicated MAM (36). However, the innovations have not been universally accepted in all countries and different countries have different formulations for therapeutic formulas.

In this review two articles reported on the treatment of Acute Malnutrition among children (14,27). Compared to the conventional standard of care for MAM treatment, these studies looked at novel methods such as the utilization of lipid-based nutrient supplements (LNS) (14) and specialized Nutrition Foods (SNF) prepared from corn-soy blend plus (CSB+) with oil, super cereal plus amylase (SC+ A) and corn-soy-whey blend with oil (27). The use of lipid-based nutrient supplements for the treatment of MAM resulted in improved Height for Age Z-scores (HAZ), Weight for Height Z scores (WHZ), Mid Upper Arm Circumference (MUAC) and weight gain (14). Kajjura *et al*., (37) compared the effectiveness of malted sorghum-based porridge (MSBP) and extruded maize and corn-soy micronutrient blend (CSB+) in the management of malnutrition among children. The study found a significant difference in mean Weight for Age Z-scores (WAZ) among the group receiving MSBP and no differences in recovery from MAM between the group that received MSBP and the group that received CSB+. Another study comparing the treatment of MAM using the standard RUSF and corn soya blend (CSB+) found no significant differences in the recovery rate (38).

McDonald *et al*., (26) reported that there is a greater improvement in all body composition parameters among Malian children who recovered from MAM after treatment and no significant differences in percentage FM change between groups supplemented with different feeds. Similarly, in the study by Suri *et al*., (27) there was a significant improvement in FFM and weight gain among children who received a four-week treatment of MAM using specialized nutritious foods. Further, Gera et a., (14) suggest that lipid-based nutrition supplements may be a slightly more effective and low-cost method than specially formulated fortified foods in the treatment and recovery of MAM among children. Evidence from these studies portrays the significance of the treatment of MAM in enhancing the body composition of children. The studies also imply the need to adopt cost-effective methods in the treatment of MAM by utilization of locally available resources to formulate feeds with similar nutrients to standard RUSF.

HIV exposure and body composition among children under 5 years

Mothers who are HIV+ may expose their children to HIV during pregnancy, childbirth or breastfeeding (39). However, measures have been put in place to prevent mother-to-child transmission and thus HIV-exposed children may either be infected or uninfected (40). In this review, we report the body composition changes among HEI, HEU and HUU children from studies across sub-Saharan Africa. HIV-infected children are at a high risk of wasting as a result of the failure of nutrients to optimally increase lean body fat as opposed to HIV uninfected children. Rickman *et al*., (21) reported that HIV-exposed infants in Kenya had a higher likelihood of belonging to the sub-optimal growth groups identified by latent class mixed modelling than the HIV-unexposed infants across all body composition models except for the sum of skinfolds. Similarly, McHenry *et al*., (22) report HEI children to have lower body composition parameters than HEU children in Kenya.

However, HEU children also experience weight, linear growth faltering (23) and poor early growth in the early years of life than HUU children which later persists in other stages of life (24). Sudfeld *et al*., (28) reported that HEU children in Botswana are at high risk of stunting. Similar findings from Nigeria show the odds of stunting in the first 18 months of life are higher among HEU children than among HUU children in Nigeria (25). Exposure to HIV proteins and glycoproteins, maternal immune compromise, and antiretroviral drugs *in utero* and via breastfeeding are some of the HIV-specific exposures which may influence child growth and development (41,42). These studies provide evidence that, despite HEI children exhibiting poor body composition parameters, HEU children are equally affected and HUU least affected. Interventions aimed at improving body composition parameters should target both HEI and HEU children.

Study limitations

A major limitation of this study is that most of the studies reviewed were done in either West or East Africa. There is a lack of published data from North, South and Central Africa thus creating a huge gap for comparison and generalization purposes

Conclusion

There exists some evidence of the inter-relationship between MAM treatment, HIV exposure, and the body composition of children. HIV exposure and infection have been shown to increase the risk of malnutrition in children who are not malnourished and exacerbate the burden of malnutrition in children with MAM. HIV unexposed uninfected children treated for MAM experience faster improvement of the body composition parameters as compared to HEI and HEU. Nevertheless, there is still a paucity of context-specific evidence from clinical trials on the linkages between acute malnutrition, HIV exposure and body composition.

Recommendations for further research

More research is needed to bridge the existing information gap on the linkages between acute malnutrition, HIV exposure and body composition. There is a need for more clinical trial research to identify better therapeutic diets in the management of MAM and the care practices for HIV-exposed children particularly in areas of widespread malabsorption illnesses.

Policy and program implications

Strategic nutrition-related intervention programs depict multi-sectoral involvement to end malnutrition including indirect policy measures needed in the prevention and management of acute malnutrition, as well as the care for HIV-exposed children. In the management of MAM among HIV-exposed infected and HIV-exposed uninfected children there should be a government policy for mandatory monitoring of body composition parameters to prevent progression into severe acute malnutrition and promote quicker recovery. This calls for the formulation of universal body composition parameters tools that will be utilized in all points of care for both clinical and community management of MAM. Countries need to develop guidelines for the formulation of supplemental foods for MAM management in case there is a shortage or unavailability of standard RUSFs.

Authors' contributions

PT was responsible for the conception and design of the study, as well as the collection, analysis, and interpretation of data, as well as the drafting and revision of the paper. In its current form, the SK, ZB, and SO oversaw the conceptualization, design, data collection, analysis, and interpretation of data, as well as the revision of the text. The final manuscript has been read and approved by all of the authors

Data availability

On reasonable request, the datasets will be made available to the interested party.

Conflicts of interest: The authors declare no conflicts of interest before and during the research

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Table 2:
Data extraction used for the studies

Study information	Study objective	Study type	Study Population	Key findings	Conclusion
Rickman *et al*., 2023, Kenya (21)	To examine the differences in body composition and growth trajectories by HIV exposure during the first 2 years of life.	Cohort study	Children below 2 years	Across all body composition models except for the sum of skinfolds, HIV-exposed infants had a higher likelihood of belonging to the suboptimal growth groups identified by LCMM than the HIV-unexposed infants.	HIV-exposed infants grew sub-optimally compared to HIV-unexposed infants beyond 1 year of age
McHenry *et al*., 2019, Kenya (22)	To determine the growth patterns, rates of malnutrition, and factors associated with malnutrition in children born to HIV-infected mothers in western Kenya using data from an electronic medical record system.	Retrospective chart review	Children below 5 years (15,428 children were analyzed, with 12,851 with HEU and 2,577 HEI)	HIV+ children tended to have larger and earlier dips in z-scores compared to HIV-exposed children, with significant differences found between the two groups ($p<0.001$) For HIV+ children assessed at 24 months, 50.9% (n = 217) were stunted, 26.5% (n = 145) were underweight, and 13.6% (n = 58) were wasted, while 45.0% (n = 577) of HEU children were stunted, 14.8% (n = 255) were underweight, and 5.1% (n = 65) were wasted.	HIV+ and HEU children differ in their anthropometrics, with HIV+ children having overall lower z-scores.
Lane *et al*., 2018, Rwanda (23)	To identify factors associated with healthy growth among HIV exposed amd HIV uninfected children	Cohort study	502 HEU children	HEU infants had moderate linear growth faltering, but only modest faltering in weight, resulting in mean weight-for-length z-score (WLZ) above the World Health Organization (WHO) median	The current WHO recommendations of Option B+ and extended breastfeeding may induce higher WLZ and lower LAZ early in infancy.
Rosala-Halas *et al*., 2017, Zambia (24)	To compare growth of HEU and HUU infants and children using data from two cohort studies in Lusaka, Zambia	Cohort study	787 HUU and 365 HEU children	HEU children had lower weight-for-age, length-for-age and BMI-for-age Z-scores during early growth	HEU children have poorer early growth than HUU children which persists into later growth.
Jumare *et al*., 2019, Nigeria (25)	To compare the growth patterns of HEU to HUU children in Nigeria	Cohort study	415 children with 307 HEU and 108 HUU	The odds of stunting and underweight were higher among HEU as compared with HUU children	Linear and ponderal growth were more impaired among HEU as compared with HUU children in Nigeria during the first 18 months of life

Table 2: (Continued)

McDonald *et al*., 2019, Mali (26)	To compare the change in percentage fat mass and other body composition parameters among young Malian children with MAM	Cluster-randomized effectiveness trial	286 children aged 6–35 months	Children who received RUSF vs. fortified flour gained more (mean; 95% CI) weight (1.43; 1.13, 1.74 kg compared with 0.84; 0.66, 1.03 kg; *P* = 0.02), FM (0.70; 0.45, 0.96 kg compared with 0.20; 0.05, 0.36 kg; *P* = 0.01), and weight-for-length *z* score (1.23;0.79, 1.54 compared with 0.49; 0.34, 0.71; *P* = 0.03).	Children who recovered from MAM exhibited greater increases in all body composition parameters, including % FM, than children who did not recover.
Suri *et al*., 2021, Sierra Leone (27)	To compare changes in body composition among children receiving 1 of 4 specialized nutritious food (SNFs) during treatment of MAM	Prospective, cluster-randomized trial	312 children	Changes in FM and FFM among 4 SNFs were similar. Children who recovered gainedmore weight (241%), FFM (179%), and weight-for-height *z* score (0.44 compared with 0) compared with those who did not recover	Four SNFs had similar effects on body composition in children after 4 wk of treatment for MAM, showinga healthy pattern of weight gain, the majority being FFM
Sudfeld *et al*., 2016, Bostswana (28)	To examine differences in anthropometric growth, comparing HEU children with HIV-unexposed uninfected (HUU) children	Cross-sectional, population-based survey	1,505 children with 396 HEU and 1,109 HUU	HEU children <1 year and ≥2 years of age had 1.85 (95% CI: 1.03–3.31; p=0.04) and 1.41 (95% CI: 1.06–1.88; p=0.02) times the risk of stunting compared with HUU children after multivariate adjustment	HEU children are at increased risk of stunting compared with their HUU peers
Gera *et al*., 2017 (14)	To evaluate the effectiveness and safety of Lipid based nutrition supplemnets (LNS) for the treatment of MAM in infants and children 6 to 59 months of age.	Systematic review of randomized-controlled trials and controlled before-after studies.	Children 6 to 59 months	There was improvement in weight gain, weight-forheight z-scores, height-for-age z-scores and mid-upper arm circumference. Subset analyses suggested higher recovery rates with greater amount of calories provided and with ready-to-use therapeutic foods, in comparison to ready-to-use supplementary foods.	Evidence restricted to the African regions suggests that LNS may be slightly more effective than specially formulated fortified foods or nutritional counselling in recovery from MAM, lowering the risk of deterioration into SAM, and improving weight gain with little impact on mortality or default rate.