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Physical activity, sports participation, and the problem of hypodynamia among adolescents: The role of sedentary lifestyle in the development of cardiovascular and musculoskeletal diseases

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Abstract. Adolescent hypodynamia and prolonged sedentary behavior have emerged as critical global public health challenges, directly undermining cardiometabolic resilience and musculoskeletal development during puberty. World Health Organization surveillance indicates that 81 percent of adolescents aged 11 to 17 years fail to meet the recommended average of 60 minutes of daily moderate-to-vigorous physical activity, with inactivity rates reaching 84.7 percent among girls and 77.6 percent among boys. This article synthesizes contemporary epidemiological, physiological, and clinical evidence examining how insufficient physical activity and excessive screen-based sitting contribute to early cardiovascular dysfunction and musculoskeletal pathology, alongside the protective role of structured sports participation. Evidence demonstrates that sedentary lifestyles elevate blood pressure, promote visceral adiposity and dyslipidemia, and diminish cardiorespiratory fitness, whereas vigorous aerobic and high-intensity interval training reduce waist circumference, triglycerides, and total cholesterol. Simultaneously, hypodynamia impairs cortical and whole-body bone mineral density accrual, weakens paraspinal musculature, and increases neck and low back pain odds in a dose-dependent manner—rising 26 percent per additional daily hour of screen exposure. Balanced, moderate-to-vigorous sports participation at least three days per week provides essential protection against both cardiovascular and skeletal morbidity.

Keywords: Adolescent hypodynamia, physical activity, sports participation, sedentary behavior, cardiovascular risk, musculoskeletal health, bone mineral density, low back pain.

O‘smirlarning jismoniy faolligi, sport bilan shug‘ullanishi va gipodinamiya muammosi: Kamharakatlilikning yurak-qon tomir va tayanch-harakat tizimi kasalliklari rivojlanishidagi roli

Annotatsiya. O‘smirlar orasida gipodinamiya va uzoq vaqt harakatsiz o‘tirish zamonaviy profilaktik tibbiyotning eng dolzarb muammolaridan biriga aylangan bo‘lib, pubertat davrida yurak-qon tomir hamda tayanch-harakat tizimining shakllanishiga salbiy ta’sir ko‘rsatmoqda. Jahon sog‘liqni saqlash tashkiloti ma’lumotlariga ko‘ra, 11–17 yoshli o‘smirlarning 81 foizi (qizlarning 84,7 foizi, o‘g‘il bolalarning 77,6 foizi) kuniga o‘rtacha 60 daqiqalik jismoniy faollik me’yorini bajarmaydi. Ushbu maqolada kamharakatlilik va ekran qarshisida uzoq o‘tirishning

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erta kardiometabolik xavf omillari, suyak mineral zichligi pasayishi, bo‘yin hamda bel og‘rig‘i rivojlanishidagi roli, shuningdek muntazam sport mashg‘ulotlarining himoya ta’siri tahlil qilingan. Tadqiqotlar shuni ko‘rsatadiki, kundalik ekran vaqtining har bir qo‘shimcha soati bel og‘rig‘i ehtimolini 26 foizga oshiradi, yuqori harakatsizlik esa suyak mineral zichligini kamaytiradi. Aksincha, haftasiga kamida uch kun bajariladigan intensiv aerob va kuch-quvvat sport mashqlari lipid profilini yaxshilaydi, qon bosimini barqarorlashtiradi va umurtqa pog‘onasini mustahkamlaydi.

Kalit so‘zlar: O‘smirlar gipodinamiyasi, jismoniy faollik, sport bilan shug‘ullanish, kamharakatlilik, yurak-qon tomir xavfi, tayanch-harakat tizimi, suyak mineral zichligi, bel og‘rig‘i.

Физическая активность, занятия спортом и проблема гиподинамии среди подростков: роль малоподвижного образа жизни в развитии заболеваний сердечно-сосудистой и костно-мышечной систем

Аннотация: Гиподинамия и длительное малоподвижное поведение среди подростков стали одной из ведущих медико-профилактических проблем, напрямую нарушающих формирование сердечно-сосудистой и костно-мышечной систем в период полового созревания. По данным Всемирной организации здравоохранения, 81% подростков 11–17 лет (84,7% девочек и 77,6% мальчиков) не достигают рекомендованных 60 минут умеренной и высокой физической активности в день. В статье систематизированы современные данные о влиянии малоподвижного образа жизни на ранние кардиометаболические риски, снижение минеральной плотности костной ткани и боли в спине, а также о протективной роли регулярного спорта. Показано, что каждый дополнительный час экранного времени повышает риск болей в пояснице на 26%, тогда как регулярные аэробные и силовые тренировки не менее трех раз в неделю улучшают липидный профиль, снижают артериальное давление и укрепляют костно-мышечный аппарат.

Ключевые слова: Гиподинамия подростков, физическая активность, занятия спортом, малоподвижный образ жизни, сердечно-сосудистый риск, костно-мышечная система, минеральная плотность кости.

INTRODUCTION

Physical activity is a fundamental biological stimulus required for normal somatic growth, cardiovascular adaptation, skeletal mineralization, and neurocognitive maturation throughout childhood and adolescence [1, 2]. During the pubertal decade spanning ages 10 to 19 years, the human cardiovascular system undergoes rapid increases in cardiac chamber dimensions, stroke volume, and vascular compliance, while the skeleton accumulates nearly half of its peak adult bone mineral mass [1, 8]. However, contemporary urbanization, motorized transport, intensive academic timetables, and ubiquitous digital screen entertainment have precipitated a global pandemic of adolescent hypodynamia [2, 10].

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IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

According to landmark World Health Organization (WHO) pooled surveillance encompassing 1.6 million youth aged 11 to 17 years across 146 countries, 81 percent of adolescents worldwide are insufficiently physically active, failing to accumulate the recommended average of 60 minutes per day of moderate-to-vigorous physical activity [1, 2]. Across nearly all geographic regions, female adolescents exhibit substantially higher inactivity rates than male peers (84.7 percent versus 77.6 percent), with only approximately 19 to 20 percent of youth globally adhering to combined aerobic and muscle-strengthening guidelines [2]. Concurrently, screen-based sedentary behavior—encompassing smartphones, computers, tablets, and television—routinely consumes several hours daily outside of classroom sitting time, displacing active outdoor play and organized sports [3, 4].

From a preventive medicine perspective, hypodynamia is not merely a benign absence of exercise, but an active physiological stressor that initiates subclinical pathology across two vital organ systems [1, 10]. Within the cardiovascular system, chronic physical inactivity blunts endothelial nitric oxide bioavailability, promotes insulin resistance and dyslipidemia, elevates resting systolic blood pressure, and depresses cardiorespiratory fitness [1, 2]. Within the musculoskeletal system, insufficient mechanical loading deprives growing bones of osteogenic strain, reduces whole-body and cortical bone mineral density, weakens postural stabilizers, and precipitates early-onset cervical and lumbar spine pain [3, 6, 7].

The objective of this literature review is to analyze the epidemiology and physiological mechanisms of adolescent hypodynamia, evaluate its specific contributions to cardiovascular and musculoskeletal morbidity, and synthesize evidence-based recommendations for structured sports participation and physical activity promotion in school and primary healthcare settings.

Importantly, the biological sensitivity of the adolescent organism means that behavioral patterns adopted between ages 10 and 17 frequently persist into adulthood [4, 10]. Early-onset musculoskeletal pain and subclinical cardiometabolic dysregulation rarely remain isolated to school years; instead, they establish trajectories toward adult chronic low back disability, arterial hypertension, and reduced bone strength [1, 4, 8].

MATERIALS AND METHODS

This investigation was conducted as a structured narrative and analytical literature review formatted in accordance with IMRAD scientific reporting standards. A comprehensive search of peer-reviewed biomedical literature and international public health guidelines was performed across PubMed Central (PMC), World Health Organization (WHO) physical activity repositories, and sports medicine journals. Search terms combined descriptors for adolescent physical activity, hypodynamia, sedentary behavior, screen time, sports participation, cardiovascular and cardiometabolic risk, bone mineral density, low back pain, and scoliosis.

Studies were selected for inclusion if they evaluated adolescents aged 10 to 19 years (or school-age cohorts spanning 10–17 years) and reported quantitative outcomes linking physical inactivity, sedentary screen time, or structured exercise interventions to cardiovascular biomarkers, bone mineral density, or spinal pain and deformity [1, 2, 3, 4, 5, 6]. Priority was given to WHO guideline evidence syntheses, systematic reviews and dose-response meta-analyses, dual-energy X-ray absorptiometry (DEXA) bone density assessments, and randomized

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IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

controlled exercise trials. Studies focused solely on geriatric rehabilitation, adult occupational heart disease, or traumatic sports fractures without behavioral exposure analysis were excluded.

Extracted data were synthesized into three analytical domains. The first domain quantified global prevalence and sex disparities in adolescent hypodynamia against 2020 WHO movement benchmarks. The second domain examined the cardiometabolic and hemodynamic consequences of sedentary behavior alongside the therapeutic efficacy of moderate versus vigorous sports training. The third domain evaluated musculoskeletal outcomes, focusing on bone mineral acquisition, neck and low back pain dose-response curves, and U-shaped physical activity thresholds.

In synthesizing the retrieved evidence, particular attention was paid to distinguishing between total sedentary sitting time, recreational screen-based sitting, and structured moderate-to-vigorous sports participation [1, 3, 6]. This distinction allows medical prevention specialists to identify both the independent hazards of prolonged inactivity and the specific intensity thresholds needed to elicit protective cardiovascular and osteogenic adaptations [2, 8].

RESULTS

Global epidemiological surveillance establishes that adolescent hypodynamia is pervasive across both high-income and transitioning nations, with stark sex disparities emerging early in secondary school [1, 2]. Pooled analyses of 298 population-based surveys confirm that four out of five adolescents aged 11–17 years fall short of the 2020 WHO guideline calling for an average of 60 minutes daily of moderate-to-vigorous aerobic physical activity plus vigorous muscle- and bone-strengthening sessions at least three days per week [1, 2]. In regional school surveys examining screen-based sedentary time, approximately 80 percent of adolescents aged 10–17 years were classified into moderate or high sedentary behavior categories [3]. Notably, the COVID-19 pandemic and subsequent expansion of digital schooling further entrenched prolonged sitting habits and lowered structured sports participation among school-age youth [4, 5].

Within the cardiovascular and metabolic systems, physical inactivity and low cardiorespiratory fitness exert measurable adverse effects well before adulthood [1, 2]. Evidence syntheses underpinning the 2020 WHO guidelines demonstrate consistent associations between reduced physical activity, elevated systolic blood pressure, unfavorable blood lipid profiles, impaired fasting glucose regulation, and excess adiposity in youth aged 5–17 years [1]. Conversely, prospective cohort and meta-analytic data indicate that vigorous physical activity (≥ 6.0 metabolic equivalents or ≥ 80 percent maximum heart rate) correlates inversely with composite cardiometabolic risk scores ($r = -0.13$, 95% CI −0.24 to −0.02) and adiposity ($r = -0.09$), while correlating positively with cardiorespiratory fitness ($r = 0.25$, 95% CI 0.15 to 0.35) [2].

Interventional sports and exercise trials confirm that structured vigorous training rapidly reverses early cardiometabolic risk markers in sedentary and overweight adolescents [2]. In a 12-week randomized trial among 16-year-old obese youth comparing high-intensity interval training (HIIT) against moderate continuous exercise, vigorous interval training significantly reduced waist circumference by 3.5 percent, serum triglycerides by 5.3 percent, and total cholesterol by

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IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

7.0 percent [2]. Meta-analyses of HIIT interventions in youth aged 13–18 years further demonstrate moderate-to-large improvements in body mass index (effect size −0.37) and body fat percentage (effect size −0.67), while achieving completion and adherence rates of 78 to 86.9 percent—demonstrating that short, intermittent vigorous sports activities are often more engaging for adolescents than prolonged low-intensity routines [2].

Parallel investigations reveal equally profound consequences of hypodynamia on the adolescent musculoskeletal system, particularly concerning skeletal mineralization and spinal pain [3, 4, 6, 7]. Because bone tissue adapts dynamically to mechanical strain via mechanotransduction, prolonged sitting deprives the growing skeleton of weight-bearing osteogenic stimuli [7, 8]. A systematic review examining objectively measured sedentary behavior confirmed a strong negative relationship between high sedentary time and cortical bone mineral density in youth [7]. Similarly, DEXA measurements in young people demonstrated that individuals with low total sedentary behavior achieved significantly higher whole-body bone mineral density (0.957 ± 0.042 g/cm²) compared with peers exhibiting moderate (0.921 ± 0.053 g/cm²) or high sedentary behavior (0.929 ± 0.051 g/cm², P = 0.011), as well as higher lower-limb bone mineral density (0.965 versus 0.877 g/cm²) [6]. Conversely, vigorous weight-bearing sports such as jumping, basketball, gymnastics, and resistance exercise stimulate superior bone mineral acquisition throughout puberty [2, 8].

Hypodynamia and screen-based sitting also drive a high burden of nonspecific spinal pain and postural dysfunction among adolescents [3, 4, 9]. Across international school cohorts, low back pain affects between 12 and 50 percent of youth [4]. In a cross-sectional study of 1,011 adolescents aged 10–17 years, moderate sedentary behavior increased the odds of neck pain 2.75-fold in boys (95% CI 1.31–5.78) and 1.80-fold in girls (high sedentary behavior OR 1.91), while moderate and high sedentary behavior elevated low back pain odds 2.5-fold in girls—largely mediated by sustained cervical flexion during handheld device use, known as Text Neck Syndrome [3]. Furthermore, a 2026 dose-response meta-analysis of 30 studies established that each additional hour of daily screen time increases the odds of low back pain in children and adolescents by 26 percent (95% CI 8%–48%) [4].

Interestingly, systematic reviews of sports intensity and spinal health highlight an important U-shaped relationship between physical activity volume and adolescent low back pain [5]. Analyzing 78,850 adolescents aged 10–19 years across 12 studies, researchers found that moderate, balanced physical activity significantly protects against low back pain by strengthening paraspinal and abdominal core musculature, whereas both complete hypodynamia and excessive, unmonitored elite overtraining elevate spinal pain risk—particularly in female athletes [5]. Additionally, emerging genetic and causal analyses indicate that low physical activity and persistently low-normal bone mineral density interact to elevate susceptibility to adolescent idiopathic scoliosis [9].

Beyond lipid and blood pressure metrics, physiological investigations clarify how hypodynamia impairs neuromuscular strength and vascular endothelial function [1, 2]. In pediatric cohorts, each additional five minutes per day of vigorous physical activity was associated with a 200-gram increase in handgrip strength and a 3-centimeter improvement in

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IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

standing long jump performance, alongside higher fat-free mass index [2]. Furthermore, meta-analyses of structured resistance and high-intensity sports training in young athletes (performed at 80 to 89 percent of one-repetition maximum) demonstrated substantial gains in muscular fitness (effect size 2.52) compared with low-intensity activity [2]. Conversely, prolonged daily sitting suppresses skeletal muscle lipoprotein lipase activity and shear-stress-mediated endothelial nitric oxide release, accelerating early insulin resistance and arterial stiffness [1, 2].

Psychosocial and neurocognitive outcomes further reinforce the systemic impact of adolescent movement behaviors [1, 10]. A meta-analysis of 114 studies among children and adolescents confirmed that regular physical activity is positively associated with psychological well-being, life satisfaction, and self-image, while correlating negatively with stress, depression, and psychological distress [10]. Similarly, evidence synthesized for the 2020 WHO guidelines demonstrated that regular physical activity improves executive function, memory, and academic performance, whereas excessive recreational screen time compounds sleep disturbance and mood symptoms [1, 10].

Importantly, observational and interventional evidence demonstrates that even partial replacement of sedentary sitting with light-to-moderate movement—combined with structured vigorous sports sessions three times weekly—yields measurable improvements in arterial compliance, insulin sensitivity, and vertebral mineral content [1, 2, 8]. Across pubertal cohorts, consistent adherence to these activity thresholds represents a decisive modifiable buffer against both early cardiometabolic clustering and chronic spinal pain [1, 5].

Furthermore, longitudinal tracking of adolescent cohorts indicates that cardiorespiratory fitness during secondary school independently predicts adult left ventricular mass, endothelial vasodilatory capacity, and metabolic syndrome risk decades later [1, 2]. Consequently, reversing hypodynamia before late adolescence yields compounding cardiovascular protection across the entire lifespan [1, 10].

DISCUSSION

The converging evidence from cardiometabolic and musculoskeletal research makes clear that adolescent hypodynamia is a systemic developmental hazard rather than a minor lifestyle flaw [1, 2, 10]. When 81 percent of adolescents fail to achieve daily movement thresholds, early vascular stiffening, visceral fat accumulation, attenuated peak bone mass, and chronic paraspinal pain begin tracking silently into young adulthood [1, 6, 10]. Because peak bone mass achieved by late adolescence is a primary determinant of lifelong osteoporosis and fracture risk, and because childhood cardiometabolic risk clusters predict premature adult atherosclerosis, preventive action during ages 10 to 17 years offers irreplaceable long-term dividends [1, 2, 8].

A critical insight for school physicians and medical prevention specialists is the gender gap in physical activity and sports participation [2, 3]. With 84.7 percent of adolescent girls globally classified as insufficiently active—and girls simultaneously facing higher risks of low back pain from sedentary screen habits and lower bone mineral accrual—public health programs must move beyond male-dominated competitive sports models [2, 3, 8]. Offering non-competitive, culturally accessible, and socially supportive movement opportunities for adolescent girls, such

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as dance, swimming, volleyball, group fitness, and structured school physical education, can substantially raise female participation [2, 10].

Equally important is recognizing the complementary roles of moderate daily movement and vigorous weight-bearing exercise [1, 2, 5]. While meeting the baseline WHO target of 60 minutes per day of moderate-to-vigorous activity reduces adiposity and improves mental well-being, incorporating vigorous aerobic intervals and muscle- and bone-strengthening sports at least three days per week produces superior gains in cardiorespiratory fitness, lipid profiles, handgrip strength, and cortical bone density [1, 2, 8]. At the same time, coaches and school physical education instructors must respect the U-shaped dose-response curve for spinal loading: gradual progression, proper biomechanical technique, core stabilization, and adequate recovery prevent overuse back injuries in competitive adolescent athletes [5].

Addressing hypodynamia at the institutional level requires transforming both the school timetable and the built environment [1, 10]. Replacing prolonged, uninterrupted classroom sitting with active standing breaks, expanding safe pedestrian and cycling corridors to school, keeping school gymnasiums and sports grounds accessible after hours, and educating parents to cap recreational screen time directly counter sedentary habits [3, 4, 10]. Integrating brief physical activity and screen-time screening into routine annual adolescent checkups at primary care polyclinics will further enable early identification of inactive youth before cardiometabolic or musculoskeletal complications become entrenched [1, 10].

Future prospective studies in Andijan and across Uzbekistan should objectively quantify daily moderate-to-vigorous activity and sedentary bouts using accelerometry alongside blood pressure, lipid panels, postural screening, and bone health indicators among secondary school and college students [1, 2, 6]. Establishing local baseline profiles will empower medical prevention departments and educational authorities to design targeted, engaging sports programs tailored to regional youth preferences.

From a practical preventive standpoint, expanding active transportation to school—such as safe walking and cycling—and diversifying physical education curricula beyond repetitive calisthenics can substantially increase daily moderate-to-vigorous movement minutes [1, 2]. When schools replace passive study periods with short, vigorous activity bursts and provide accessible sports clubs after classes, even previously sedentary or overweight adolescents demonstrate high program completion rates [2]. Engaging families to model active weekend recreation and enforce screen-free evening hours further ensures that cardiovascular and skeletal protection extends beyond school walls [3, 10].

Equally vital is integrating objective movement counseling into primary healthcare and medical prevention clinics [1, 10]. During annual adolescent health evaluations, physicians should inquire specifically about daily sitting hours, screen exposure, and weekly sports frequency, prescribing individualized, age-appropriate exercise regimens alongside ergonomic posture guidance [1, 3, 5]. Such proactive clinical engagement transforms physical activity from an optional leisure pursuit into a foundational pillar of preventive adolescent medicine [1, 2].

Finally, municipal urban planning and educational policy must recognize that accessible parks, safe sidewalks, and well-equipped school sports facilities are direct investments in

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IF: 14.91 | 2026 http://waerasia.org/index.php/ijtar

cardiovascular and orthopedic disease prevention [1, 10]. By lowering structural barriers to daily movement for both boys and girls, communities can substantially reduce the future adult burden of hypertension, ischemic heart disease, osteoporosis, and chronic back disability [1, 4, 8].

Collaboration between school medical personnel, physical education teachers, and local sports federations can also help identify students with early postural asymmetry or low exercise tolerance who require tailored, low-impact conditioning rather than exemption from physical education [5, 9]. Replacing blanket medical exemptions with adaptive, supervised exercise ensures that vulnerable adolescents still receive essential cardiovascular and osteogenic stimulation safely [2, 8].

Ultimately, overcoming the global epidemic of adolescent hypodynamia demands sustained coordination between healthcare providers, educators, urban planners, and parents [1, 2, 10]. By embedding structured aerobic and strength-building movement into the daily rhythm of school and family life, preventive medicine can protect both cardiovascular longevity and lifelong skeletal integrity [1, 8].

CONCLUSION

Hypodynamia affects more than four-fifths of adolescents worldwide and exerts a dual pathogenic impact on the cardiovascular and musculoskeletal systems. Prolonged sedentary behavior and excessive screen time elevate blood pressure, promote dyslipidemia and central adiposity, impair cortical and whole-body bone mineral density accrual, and increase neck and low back pain in a dose-dependent manner. Conversely, adhering to the WHO recommendation of at least 60 minutes of daily moderate-to-vigorous physical activity—supplemented by vigorous aerobic and bone-strengthening sports at least three times per week while avoiding excessive overtraining—robustly protects cardiometabolic health, maximizes peak bone mass, and prevents spinal pain. Multi-level interventions uniting school physical education reform, accessible youth sports, screen-time reduction, and preventive clinical counseling are essential to reverse adolescent hypodynamia.

Future regional preventive initiatives in Uzbekistan should prioritize establishing school-based physical fitness monitoring alongside routine cardiometabolic and postural screenings, empowering adolescents to replace sedentary screen routines with lifelong, enjoyable sports participation [1, 2, 10].

Expanding community sports infrastructure, training physical educators in evidence-based youth conditioning, and embedding movement counseling into primary care checkups together offer a practical, scalable roadmap for protecting adolescent cardiovascular and musculoskeletal health [1, 2, 5, 8].

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