EXERCISE PROGRAM OF THE MUBI PROJECT

This exercise programme was specifically designed for the MUBI (MUévete BIen) Project, which aims to test the combined effects of exercise on walking kinematics, dynamic plantar pressure of gait, body posture, movement competency and physical fitness in children between 8 to 12 years old with overweight/obesity.

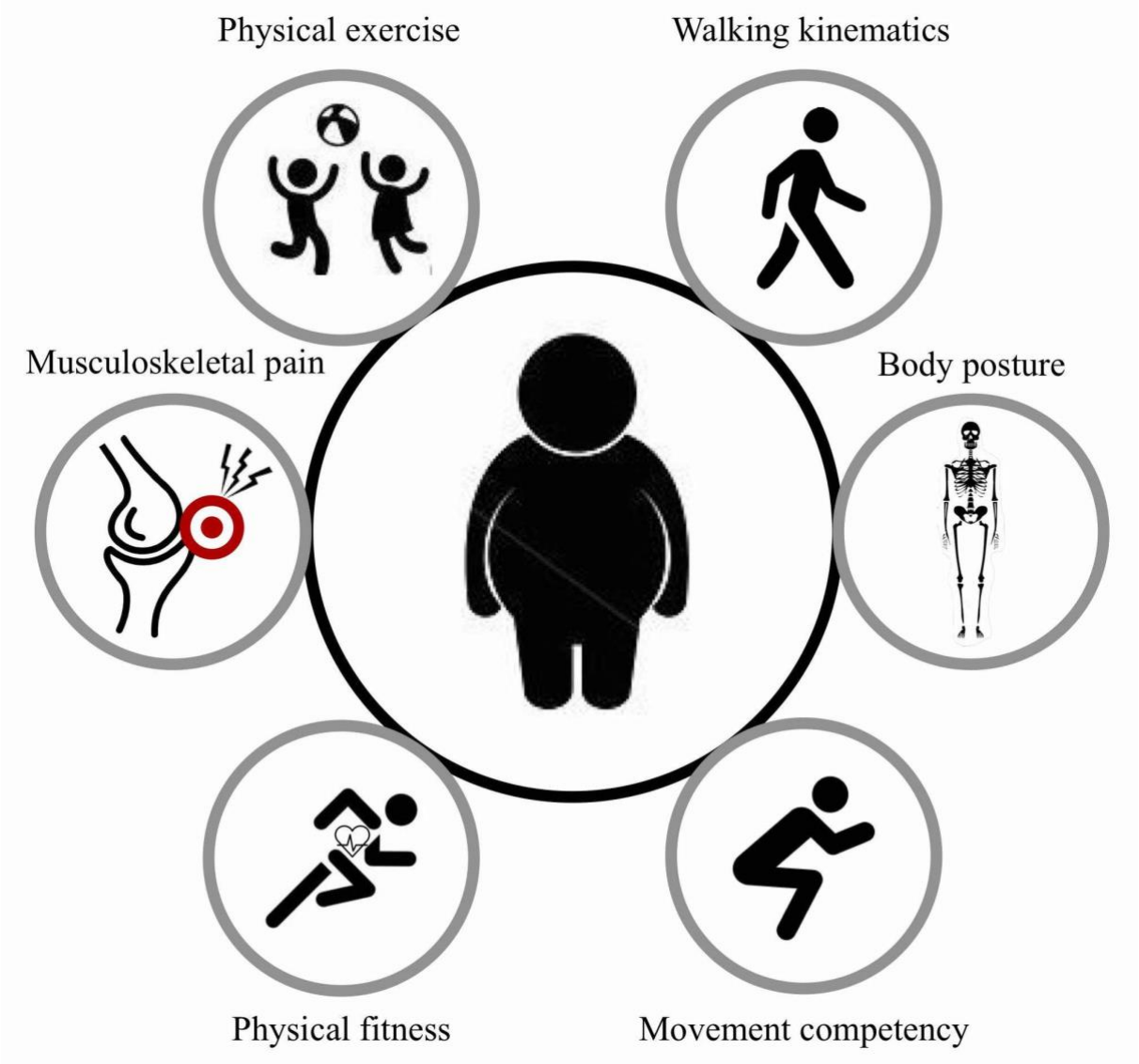


Figure 1. Graphical representation of the included variables in the MUBI project

1. Why children with overweight/obesity?

The presence of overweight/obesity during childhood is considered as one of the most serious health problems of our time.[1] Among other consequences, paediatric obesity negatively affects

their gait pattern biomechanics, feet morphology and functioning, body posture, movement competency and physical fitness level.[2–6] This adverse consequences of children with overweight/obesity, compared to their healthy-weight peers, could have devastating implications on their musculoskeletal system, metabolic and cardiovascular profiles, and normal cognitive and social development.[7–10] In this sense, physical exercise intervention is considered as an effective treatment to combat obesity in children and its harmful implications.[11] However, there is still a lack of evidence demonstrating that physical exercise interventions can induce positive changes in the biomechanics of gait, feet functioning while walking and body posture.[12,13] Likewise, although previous systematic reviews have demonstrated the effectiveness of exercise interventions improving movement competency and health-related physical fitness components,[14,15] little is known about the combined effects of exercises on all the above-mentioned variables.

2. Exercise program description

The exercise programme had a total duration of 13-weeks, starting the 1st of March 2017 and ending the 26th of May 2017, and was run at the Institute for Mixed Sport and Health Sciences (iMUDS) belonging to the University of Granada. Sessions were conducted by a minimum of two sport science students, who received extensive training for supervising this exercise programme.

Following previous trial strategy,[16] group sessions were run every weekday where participants were asked to attend a minimum of 3 sessions per week. This helped to logistically facilitate attendance, allowing participants to select the 3 days that best fit for them and also giving them the possibility to attend the 5 sessions.

Each session had a total duration of 90 minutes, and was divided in two different parts: 30 minutes of ‘movement quality’, and 60 minutes of the ‘multigames’. The ‘movement quality’ part of the session was conducted in the gymnasium. The main objectives of this part were that participants acquired awareness of analytic movement mechanics (e.g., anterior and posterior pelvic tilt) and body posture (e.g., optimal spine position), gained body segment mobility (e.g., hip flexion mobility), stability (e.g., core stability) and muscular strength in functional range of motion (e.g., bilateral lower-limb push strength), and learned basic human movements (e.g., squat pattern). The ‘multigames’ part of the session was conducted in an outside sport court. Its

main objectives were that participants reached a moderate-to-vigorous aerobic intensity, learned and assimilated a wide range of fundamental movement skills (e.g., sprinting, hopping or throwing), and to enjoy while practising physical exercise. In coordination with the children's parents, "exercise homework" was provided for Easter holidays. No specific dietary intervention was conducted in the participants neither in the exercise nor in the control group.

3. Training methodologies included in the exercise program

The exercise program design was inspired on different training methodologies, specifically selected to address the above mentioned impairments in children with overweight/obesity. Below, is provided a brief definition of these methodologies, the rationale of its inclusion, and the description of how we incorporated them in the exercise program.

3.1. Physical activity guidelines for children

The starting point for the exercise program design was the internationally accepted physical activity guidelines (http://www.health.gov/paguidelines/) for children. These guidelines recommend children to exercise daily, and, therefore, we offered the possibility to attend to the exercise programme daily from Monday to Friday. However, considering that Spanish children usually have 2 sessions of physical education at school, our participants were asked to attend a minimum of 3 sessions per week. Physical activity guidelines also recommend that, within the daily recommended activity, 3 days should include vigorous-intensity physical activity and resistance training. For that reason, one of the objectives of our 'multigame' part of the session was to reach a moderate to vigorous intensity, besides our aims of improving 'movement quality' and gaining of muscle strength.

3.2. Position statement on youth resistance training

Far from previous beliefs that children should not practise resistance training, nowadays it is strongly recommended that children and adolescents include this training modality within their physical exercise routines. We have based the present training program on the 'Position Statement on Youth Resistance Training' to design and incorporate resistance training into our 'movement quality' part of the session.[17]

3.2.1. Exercise selection

The main premise in the exercise selection was 'quality in the execution over quantity or load'. Exercise technique was always the main goal, and coaches in charge of sessions were instructed to provide comprehensive technical explanations of each exercise, and give personalized feedback when necessary. We attempted to progressively introduce global bodyweight exercises (e.g. squatting or lunging) and elastic resistance band exercises (e.g., pressing or pulling movements), but it is important to note that our participants were children with overweight/obesity, that overall demonstrated low levels of movement competency and physical functioning. Thus, progression strategies were included through the Dynamic Neuromuscular Stabilization and Integrative Neuromuscular Training approaches that we will explain later in detail.

3.2.2. Training volume and intensity

Percentage of an individuals' one Repetition Maximum (1RM) is the most common way to prescribe and control resistance training intensity, but in an untrained population, as is the case of this exercise intervention, the use of 1RM is unnecessary.[17] Instead, we first focused on the development of technical competency in each exercise by using low volume and intensity (e.g., 1 set of 2-5 repetitions or 1-2 min of execution time for exercises in pairs), and, above all, emphasizing to children that they should perform each repetition 'slowly and controlled' and 'putting attention on the movement'. Once children learned and mastered exercises, we progressed in volume and intensity, as well as exercise complexity (e.g., 2 set of 5-10 repetitions or 2-3 min of execution time for exercises in pairs).

3.2.3. Repetition velocity

Execution velocity of our exercises in the 'movement quality' part progressed both, within session and within the training program. Within session, children started with slower and controlled exercise repetition, with less challenging positions such as prone or quadruped, and they finished with rapid exercise that prepare their neuromuscular system to the explosive movement that they performed in the 'multigames' part. Within the training program, coaches encouraged to increase repetition velocity once they noted that technical execution was correct.

3.3. Dynamic Neuromuscular Stabilization approach

The Dynamic Neuromuscular Stabilization (DNS) approach was developed by Professor Pavel Kolar, a Czech physiotherapist from the Prague School of Manual Medicine.[18] DNS proposes

Table 1. Example of the exercise-position progression followed in the 'movement quality' part of the session.

LOWER-LIMBS DEAD BUG	**ROLLING PATTERN**	**FRONT PLANK**
		
Position: supine	**Position:** supine to prone	**Position:** prone
LATERAL PLANK	**CRAWLING**	**BIRD-DOG**
		
Position: lateral	**Position:** quadruped, 4 points	**Position:** quadruped, 2 points
BILATERAL HORIZONTAL PULL IN	**UNILATERAL HORIZONTAL PULL**	**SPLIT IN PAIRS**
		
Position: tall kneeling	**Position:** half kneeling	**Position:** split
SQUAT IN PAIRS	**RAPID RESPONSE BILATERAL**	**SINGLE LEG DEADLIFT**
		
Position: squat	**Position:** base position	**Position:** one leg

to restore an optimal body posture and movement patterns through exercise-position progressions based on the normal development of a healthy baby [18]. The 'movement quality' part of the session always followed this type of exercise-position progression (**Table 1**): prone, supine, lateral, quadruped with 4, 3 and 2 points of support, tall-kneeling, half-kneeling, split, squat, base position and one-leg. The session always started with the initial development positions (i.e., supine and prone positions) that are less challenging for children in terms of stabilization demands, and ended with more challenging positions (i.e., split, squat and base position). When initial exercise positions were mastered, we progressed in difficulty by starting the session with more demanding exercise positions. The two trainers in charge of the session emphasised acquiring and maintaining a correct body posture in each exercise-position through visual demonstrations and comprehensible instructions specifically designed for children (e.g., "we are rigid like a stone statue" for stability exercises). Lastly, trainers encouraged the children to do the exercises slow and controlled, always putting awareness in their posture, movement and breathing.

3.4. Barefoot training

Previous observational studies have identified that being habitually barefoot has positive effects on the overall health of children and adolescents' feet, expressed with less prevalence of flatfeet, among others indicators.[19,20] Likewise, one previous study has demonstrated that specific barefoot exercises (i.e., short foot exercise) can improve the foot posture, as well as to

Table 2. Some examples of barefoot exercises included.

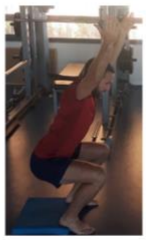
FOOT TRIPOD	SHORT FOOT	GAIT FOOT PATTERN
		
Position: split and stand **Description:** distribute the body weight under the 1st metatarsal head, 5th metatarsal head, and heel.	**Position:** split **Description:** find the foot tripod, spread the toes and place them into the ground. In this position, push the big toe down into the ground for 10 seconds.	**Position:** stand **Description:** learn the rollover foot pattern: 1st the heel, 2nd the 5th metatarsal head, 3rd the 1st metatarsal head, and 4th the big toe.

improve the functional movement patterns in long distance runners.[21] Based on this evidence, the whole 'movement quality' part of the session was fully performed barefoot, as well as including specific exercises to train the gait pattern (i.e., gait foot pattern exercises) and to activate intrinsic muscles of the feet (i.e., foot tripod and short foot exercises) (**Table 2**). The inclusion of this barefoot training was expected to help in the activation and strengthening of some key muscles, such as tibialis posterior or flexor hallucis longus, flexor digitorum brevis and abductor hallucis, with also positive adaptations of the bones and ligaments of our participants' feet.[19] Furthermore, exercising barefoot could be enhancing a richer environment for the plantar proprioceptors of our participants, being therefore beneficial in maintaining balance, stimulating small nerves of the foot, and getting proximal and distal joint stability.[22]

3.5. Integrative Neuromuscular Training

The most recent position statement on strength training in youth proposes the inclusion of integrative programs enhancing muscular strength together with movement competence and motor proficiency.[17] Our exercise program was designed following this philosophy by including the principles of Integrative Neuromuscular Training in each session. Based on the review of Myer GD et al.,[23] the Integrative Neuromuscular Training can be defined as a supplemental training program that incorporates general movement pattern (e.g., basics human movement and fundamental movement skills) and specific strength and conditioning exercises (e.g., analytic motor control, mobility and stability) targeted to reconditioned movement mechanics deficits. In this sense, our 'movement quality' part incorporated exercises focusing on analytic motor control (e.g., find and maintain the neutral lumpopelvic or spine positions), mobility (e.g., rolling patterns or hip mobility), stability (e.g., glute bridges or planks) and basic movements (e.g., squat or upper body pulls), whereas the 'multigames' part included activities enhancing fundamental movement skills (e.g., sprinting, hopping or throwing). All these components attempted to: 1) restore normal movement mechanics possibly altered as a consequence of the excess of body weight, 2) learn and master basic human movements inherent to humans,[24] 3) gain muscle strength and motor control in functional range of motion, 4) learn and master fundamental movement skills, and 5) gain confidence in their physical functioning.

Table 3. Example of an exercise progression for the squat pattern

PELVIS ANTERIOR-POSTERIOR TILT	LOWER-LIMBS DEAD BUG	MINI BAND SIDE-CLAM
		
Motor control: to find the neutral lumbopelvic position	**Motor control:** to maintain the neutral lumbopelvic position	**Mobility:** hip joint dissociation and mobility
FRONT PLANK	**LATERAL PLANK**	**CAT-CAMEL**
		
Stability: core stability (sagittal plane)	**Stability:** core stability (frontal plane)	**Motor control:** to find the neutral spine position
CRAWLING	**SQUAT IN PAIRS. HEEL ELEVATED**	**OVER HEAD SQUAT IN PAIRS**
		
Motor control: to maintain the neutral spine position	**Integration:** squat pattern progression (first stage)	**Integration:** squat pattern progression (last stage)

Regarding the organization of the Integrative Neuromuscular Training components, each 'movement quality' session had as a global objective the execution of a basic human movement. To achieve this objective, an exercise progression was included targeting the necessary component to optimally execute this basic human movement, always including these exercises: 1) mobility, 2) stability, 3) analytic motor control, and 4) integration of the basic human movement. For instance, the 'squat pattern' session included exercises aimed to: 1) mobility:

to dissociate the hip with respect to the lumbopelvic complex and to get hip mobility in the sagittal plane, 2) stability: to improve the core and lumbopelvic stability in different planes of movement, 3) analytic motor control: to find and maintain the neutral position of the lumbopelvic complex and the spine, and 4) integration: squat pattern progression. To see an example of these exercises, we refer to **Table 3**.

4. Duration and periodisation of the training program

The training program was divided in 2 phases, graphically shown in **Table 4**. Phase 1 had a duration of 5 weeks and included sessions 1.1 to 1.4 on a rotary basis. Phase 2 was a progression in exercise complexity and alternated sessions 2.1 and 2.2 from Monday week 6 to Friday week 13, except week 7 in which participants completed an Easter home exercise program.

Table 4. Graphical organization of the exercise program, divided in two phases.

WEEKS	MOVEMENT QUALITY PART					PHASES
	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	
1	1.1	1.2	1.3	1.4	1.1	PHASE 1
2	1.2	1.3	1.4	1.1	1.2	PHASE 1
3	1.3	1.4	1.1	1.2	1.3	PHASE 1
4	1.4	1.1	1.2	1.3	1.4	PHASE 1
5	1.1	1.2	1.3	1.4	1.1	PHASE 1
6	1.2	1.3	1.4	1.1	1.2	PHASE 1
7	Easter Home Training Program					
8	2.1	2.2	2.1	2.2	2.1	PHASE 2
9	2.2	2.1	2.2	2.1	2.2	PHASE 2
10	2.1	2.2	2.1	2.2	2.1	PHASE 2
11	2.2	2.1	2.2	2.1	2.2	PHASE 2
12	2.1	2.2	2.1	2.2	2.1	PHASE 2
13	2.2	2.1	2.2	2.1	2.2	PHASE 2

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