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CASE REPORT

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Impact of quadriceps strength training along with aerobic exercise on physical performance in a sedentary obese woman with type 2 diabetes: A case report

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Abstract

Background: Sedentary behaviour, chronic metabolic conditions like type 2 diabetes, and excess adiposity accelerate physical function decline in young adults. Lower limb deconditioning, specifically quadriceps weakness, is implicated in accelerated fatigability, impaired balance, and reduced exercise tolerance. While independent benefits of resistance or aerobic training are known, few reports document a structured, combined progressive protocol targeting both functional deconditioning and metabolic parameters in this population. This case demonstrates the multi-system clinical efficacy of a low-cost, minimal-equipment protocol for primary care settings.

Methods: A 38-year-old sedentary woman with a 3-year history of obesity and type 2 diabetes mellitus presented with early-onset exertional fatigue, low musculoskeletal endurance, and poor glycaemic control. A supervised, progressive, 6-week multimodal program (three sessions per week) combined low to moderate quadriceps strength training with aerobic conditioning, at intensities from 40% to 80% $HRmax$, and durations to 40 minutes.

Results: Pre- and post-intervention assessments revealed broad-spectrum improvements across all metrics. Aerobic capacity VO_2 max improved 19% (32.4 to $38.7ml/kg/min$), single-leg stance balance improved 59% (22 to 35 s), agility times dropped 13%, and reaction time quickened by 21%. Exertion and respiration improved, with perceived exertion (Borg RPE) decreasing by 27% and Peak Expiratory Flow Rate increasing by 21%. Cardiovascular health markers normalized, and metabolic health significantly improved, demonstrating a substantial reduction in both fasting and postprandial blood sugar levels (BSL).

Conclusion: In this sedentary patient with obesity and type 2 diabetes, a 6-week program combining progressive quadriceps strength training with moderate aerobic conditioning was associated with functional and short-term metabolic improvements. Larger controlled studies are warranted to establish generalizability and long-term efficacy.

KEYWORDS

Aerobic conditioning; Diabetes mellitus; Glycaemic control; Obesity; Physical performance; Quadriceps muscle strengthening; Case report

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Introduction

Sedentary behaviour, obesity, and metabolic conditions such as type 2 diabetes mellitus cause an early decline in physical function, even among younger adults. Reduced exercise capacity, poor balance, and increased fatigability have been related to lower limb muscle weakness, particularly quadriceps muscles [1-3]. Quadriceps deconditioning often initiates a vicious cycle of decreased physical activity and progressive muscle atrophy [3]. The strength of quadriceps muscles is very crucial for daily activities, climbing stairs, and maintaining the upright position during active activities.

There are numerous benefits from aerobic exercises already proven; however, few studies have investigated the combined use of physical and metabolic therapy in patients with sedentary behaviour, obesity, and diabetes [4,5]. Although previous studies have shown that separation of such approaches leads to different pathways of strength or cardiovascular improvement, integrated approaches are underused in primary care [6]. In combination with respiratory exercises, an aerobic exercise program promises the results from metabolic conditioning as well [7]. This case study will provide a highly effective, integrated approach to treatment of young adults' circulatory, muscular, and metabolic systems.

Patient Information

A 38-year-old woman who is a healthcare professional had low musculoskeletal endurance and premature exertional fatigue. The patient had a 3-year history of obesity and type 2 diabetes mellitus attributed primarily to a prolonged sedentary lifestyle. Her previous medical records indicated suboptimal long-term glycemic control, with a prior HbA_{1c} of 7.6%. She stated that she maintained her diet and anti-diabetic medications(Metformin 500 mg BD) as prescribed by her physician during her 6 weeks of intervention & simple activities such as walking for 15 minutes and going up two floors of stairs would make her feel exhausted. She also expressed concern regarding declining functional capacity and localised adiposity in the lower limbs. Her initial body mass index and body composition using the Asian Pacific scale were found to be in the obese category, i.e. 25.7 kg/m^2.

Her initial fatigue was felt as heaviness and tiredness in her muscles, particularly in her thighs and lower back regions. She felt exertion while performing light activity such as grocery shopping and household chores, with a score of 5-6 out of 10 on the modified Borg rating of perceived exertion (RPE). She never experienced any episodes of falls, syncope or cardiopulmonary distress.

Physical assessment revealed that the young lady was healthy but had a mild anterior pelvic tilt, rounded shoulders and forward head due to an inactive lifestyle. The physical assessment of the lower limb had no evidence of any joint deformity, effusion or swelling. The grade of the quadriceps was 4/5 bilaterally in the MMT. The Single Leg Stance Test had a duration of 23 seconds on the left leg and 22 seconds on the right leg (normal>30 seconds).

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Assessment of functional capacity was done using the Queen's College Step Test (a 3-minute step test at 22 steps per minute for women). The estimate of the VO2 max was 32.4 ml/kg/min which put her in the fair category of cardiorespiratory fitness for her age [8]. The resting heart rate was 82 beats/minute while the blood pressure was 130/90mmHg, pre-hypertensive. Peak Expiratory Flow Rate (PEFR) was 370 litres/minute. The Illinois agility test gave 22.6 seconds which requires a participant to start face-down behind a line, sprint 10 meters forward, and then return back to the baseline. From there, they weave in and out around four vertically aligned cones over a 10-meter distance before finishing with a final 10-meter out-and-back sprint and the simple reaction time was 310 milliseconds which is a simple, low-cost method designed to evaluate a participant's visual-motor reaction time. A tester drops a vertically held ruler without warning, requiring the participant to catch it immediately. The subject must grab the ruler between their thumb and index finger as quickly as possible. The distance the ruler falls is recorded in centimeters and converted into milliseconds to determine the final reaction time. Metabolic parameters indicated poor glycaemic control because the pre-intervention Fasting Blood Sugar Level (BSL Fasting) was 142mg/dl and Postprandial Blood Sugar Level (BSL Post) was 198mg/dl.

The patient had been suffering from physical deconditioning and poor glycaemic control due to her sedentary academic way of living, obesity, and diabetic state, along with her poor condition of quadriceps muscles leading to poor functional capacity.

Due to the young age of the patient and high level of motivation, her prognosis regarding the process of physical and metabolic recovery was very good, provided the right kind of physical stimulus was provided.

Intervention

The patient underwent a supervised, progressive 6-week multimodal exercise program consisting of three sessions per week (18 sessions in total). The rationale for this 6-week timeframe was to provide sufficient stimulus for early neural, metabolic, and glycaemic adaptations without risking overuse injuries in a previously sedentary individual.

Each session lasted 45-60 min and included four components:

Warm-up (5 minutes)

ROM of all joints, followed by dynamic stretching of the lower limbs.

Quadriceps strengthening (20-25 minutes)

Three exercises were performed in sequence:

- Body-weight squats: Starting with partial squats (60° knee flexion), progressing to full squats (90° knee flexion) by week 3, with a goal of three sets of 12-15 repetitions.
- Forward lunges: Alternating legs, progressing from two sets of eight to three sets of 12 repetitions by week 4.
- Resisted knee extension: Using elastic resistance bands (TheraBand), starting with yellow (extra-light) resistance and progressing to red (medium) by week 4, for three sets of 15 repetitions.
- Progression: The patient rested for 45-60 seconds between sets. Resistance was increased when the patient could complete three sets of 15 repetitions with good form and without exceeding a Borg RPE of 4 (moderate).

Aerobic conditioning (20-30 minutes)

The patient alternated between treadmill walking/jogging and stationary cycling. Target heart rate zones were set using the Karvonen formula based on the age-predicted maximal heart rate ($HR_{max} = 220 - age$). Intensity was scaled from 40% HR_{max} (weeks 1-2) to 60% HR_{max} (weeks 3-4), and finally to 75%

HR_{max} (weeks 5-6). The session duration progressed from 20 min (weeks 1-2) to 30 min (weeks 3-4) and 40 min (weeks 5-6). Heart rate was continuously monitored using a pulse oximeter during the intervention. Capillary blood glucose was monitored periodically to ensure exercise safety and track glycaemic fluctuations.

Cool-down (5 min)

ROM exercises of all joints, followed by diaphragmatic breathing.

The intervention proceeded exactly as planned without modifications.

Adverse Events

There were no adverse or unanticipated events during the 6-week program. The patient did not experience any symptomatic hypoglycemia, muscle strains, abnormal joint pain, or excessive prolonged fatigue following the exercise sessions.

Outcomes and Follow-up

Pre- and post-intervention assessments were performed at baseline (Week 0) and after program completion (Week 6). The results are summarized below (Table 1).

Table 1. Pre- and post-intervention clinical, functional, and metabolic outcomes.

Parameter	Pre-intervention	Post-intervention	Change
Estimated VO_{2max} [$mL \cdot kg^{-1} \cdot min^{-1}$]	32.4	38.7	+19%.4%
Simple Reaction time (ms)	310	245	−21.0%
Borg RPE (at submaximal workload)	5-6	3-4	-27.0%
Single-leg stance balance (s)	22	35	+59.1%
Illinois Agility Test(s)	22.6	19.7	-12.8%
Reseating Blood Pressure (mmHg)	130/90	120/80	Normalized
Resting heart rate (bpm)	82	74	-9.8%
Peak Expiratory Flow Rate (PEFR)	370	448	+21.1%
Fasting Blood Sugar (BSL Fasting) (mg/dL)	142	106	-25.4%

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Table 1 (continued)

Parameter	Pre-intervention	Post-intervention	Change
Postprandial Blood Sugar (BSL Post) (mg/dL)	198	140	-29.3%
Quadriceps Muscle Strength MMT	4/5	5/5	Improved

Adherence

The patient demonstrated 100% compliance, adhering to all 18 scheduled sessions.

Discussion

This case study provided the successful execution of aerobic conditioning and quadriceps strengthening intervention in a 38-year-old sedentary woman suffering from obesity and diabetes mellitus for three years owing to her academic nature of work. There were significant improvements in neuromuscular function, cardiopulmonary health, perceived effort, cardiorespiratory fitness, and metabolic state.

The predicted increase in VO_2 max was 19%, which is significant and greater than the average 10-15% gain from deconditioned people after performing only aerobic exercises [9]. These cardiorespiratory gains may potentially be explained by peripheral vascular and cellular adaptations, such as enhanced skeletal muscle capillarization and improved peripheral oxygen extraction$(a - vO_2 difference)$, rather than directly measured central cardiac changes [10]. It is consistent with scientific data from a structured 6-week program indicating better local and general physiological variables with respect to the use of concurrent exercise technique [11,12].

The most impressive 59% improvement in single-leg stance balance must be noted here; the quadriceps strength may have positively affected proprioception at the knee and helped to develop better rapid change-of-position capacity of the muscle and thus contributed to balance [13]. Systematic analogue and reactive coordination measurements of these components show that the stress on lower limbs causes stable sensory-motor changes [14,15].

These hemodynamic responses likely reflect favourable autonomic modulations (such as increased parasympathetic tone or decreased sympathetic drive), while the gain in PEFR may be associated with improved chest wall compliance and respiratory muscle efficiency. [12]. This is very important because even the slightest blood pressure lowering in youth lowers the lifetime risks of cardiovascular events [16]. The better thoracoabdominal coupling during exercise and the enhancement of the functioning of the respiratory muscles because of aerobic fitness could be responsible for the 21% gain in PEFR [7,17]. The 27% fall in Borg RPE indicates that the patient had succeeded in doing the same or higher load with lesser effort perception. This psychologic transition is required for sustained physical activity adherence.

Significant changes in fasting and postprandial blood glucose before and after the intervention indicate the high efficiency of this method in terms of metabolic stabilisation. Skeletal muscle accounts for the majority of insulin-stimulated glucose uptake. A probable physiological explanation is that muscle contractions stimulate GLUT4 glucose transporter translocation to the cell membrane via insulin-independent pathways (such as AMPK activation), which may have contributed to the observed glycemic improvements [18].

Limitations

Being a single case study, this conclusion cannot be drawn without replication in further controlled trials [19,20]. This 6-week follow-up proved relatively successful. The use of the Queen's College Step Test yields an estimation of the VO2 max rather than its actual measurement [8]. Furthermore, implementation of multiple agility profile tests (like Illinois agility test) will enable us to discover any mechanical differences at various training volumes; however, further blocks of trial are required to separate out any motivational factors [21-23]. A notable limitation of this study is the reliance on MMT rather than objective isokinetic dynamometry. While MMT provides practical clinical utility, it is an ordinal, semi-quantitative scale subject to potential ceiling effects (Grade 5/5) and examiner subjectivity. Consequently, it cannot quantify continuous variables such as peak torque, angular velocity curves, or rate of torque development across the full range of motion, which limits the precision of the documented lower-limb neuromuscular gains.

Clinical Implications

In contrast, the current case provides evidence for the success of deconditioning reversal in sedentary young females with obesity and diabetes through a simple, inexpensive and equipment-lean regimen combining gradual quadriceps exercise with moderate aerobic exercise. Resistance bands, a treadmill, and a stationary cycle all of which are frequently found in primary care and community physiotherapy settings were the only equipment needed for the program.

In dealing with such patients in the future, researchers should take into account the use of combination aerobic exercise and specific quadriceps exercise, especially in patients with glycaemic dysregulation, limb weakness, and balance issues. Future research should be geared towards studying whether an independent home-based maintenance regimen can provide the same benefits and test the effectiveness of the regimen on larger sample sizes.

Conclusion

This patient's functional mobility, perceived exertion, and short-term glycaemic markers all improved with a 6-week structured regimen that combined progressive low-to-moderate quadriceps strength training with aerobic exercise. This minimal-equipment technique shows an effective approach that justifies systematic exploration in bigger cohorts with comprehensive metabolic endpoints, even though the single-case design restricts causation certainty and wide therapeutic use.

Patient's Perspective

Initially, the patient reported very hopeful subjective improvement, saying that by week three, she was able to go about her regular activities with noticeably less leg heaviness. By week six, she reported that she had a lot more energy and could walk the stairs at her job without stopping. She was extremely driven to keep up her fitness on her own and expressed great satisfaction with the program's ease of use.

Disclosure Statement

The authors declare no conflicts of interest.

Statement of Patient Consent

Written informed consent was obtained from the patient for publication of this case report and any accompanying data.

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Author Contribution Statement

Ms. Annaglory Janwadkar designed the study, conducted clinical evaluations, delivered the exercise intervention, assisted in data analysis, and drafted the manuscript. Dr. Vishvnath S. Pawadshetty supervised the clinical intervention and critically revised the manuscript. Both authors read and approved the final text.

Data Availability Statement

The data supporting the findings of this study can be obtained from the corresponding author on reasonable request. Because of institutional data-sharing policies and the need to protect participant privacy, the datasheet itself has not been made publicly available.

AI Disclosure Statement

During the preparation of the work, the author used Gemini AI for references and text-paraphrasing tools -QuillBot & Paperpal to assist with grammar refinement, word-choice variation, and structural formatting of this manuscript. The authors thoroughly reviewed, edited, and take full responsibility for all scientific data, interpretations, and final content presented in this work. Use of Humanize AI & Sapling AI tools to analyze AI detection.

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