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Patient-selected music listening and heart-rate patterns during paediatric dental hygiene: an exploratory pilot study



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Abstract

Background Dental procedures may elicit fear and anxiety in children, potentially affecting cooperation and the overall quality of care. Music listening is a simple, low-cost, non-pharmacological intervention that can be easily integrated into preventive dental procedures. However, physiological measures such as heart rate (HR) are non-specific and should not be interpreted as direct measures of dental anxiety, fear, or behavioral cooperation.
Aim To explore heart-rate changes across predefined procedural phases in paediatric patients undergoing professional dental hygiene with passive patient-selected music listening compared with standard care, and to descriptively examine HR patterns in a small clinically indicated nitrous oxide/oxygen (N_2O/O_2) conscious sedation reference group.
Study Design Single-center exploratory pilot study.
Materials and Methods This single-center pilot study included 45 children aged 5–14 years undergoing scaling and polishing. Participants were allocated to Group A (standard care; n=19), Group B (passive patient-selected music listening via headphones; n=21), and Group C (clinically indicated N_2O/O_2 conscious sedation; n=5; non-randomised reference group). Groups A and B were assigned by simple randomization, whereas Group C was not randomised. HR was recorded by fingertip pulse oximetry throughout the appointment and summarised at three predefined procedural phases: before the procedure (T0), during scaling (T1), and at the end of the session (T2).
Results Mean HR values (bpm) at T0, T1, and T2 were 98.0, 90.0, and 95.3 in Group A; 95.7, 84.5, and 80.1 in Group B; and 97.6, 79.2, and 73.4 in Group C, respectively. Compared with Group A, Group B showed a greater reduction in mean HR from baseline to the end of the session (–15.6 vs. –2.7 bpm). The clinically indicated N_2O/O_2 reference group showed the lowest mean HR values during scaling and at the end of the session. These comparisons were descriptive only.
Statistics Data were analysed descriptively. HR values were summarised as group means at the three predefined procedural phases, and changes across time points were reported as differences between group mean values. No formal inferential statistical testing was performed because of the exploratory pilot design and limited sample size.
Conclusions In this exploratory pilot sample, passive patient-selected music listening was associated with a different pattern of HR change across the dental hygiene session compared with standard care, with lower mean HR values observed during scaling and at the end of the session. Because HR is a non-specific physiological parameter and no validated psychological or behavioural measure of dental anxiety, fear, or cooperation was collected, these findings should be regarded as preliminary and hypothesis-generating and should not be interpreted as evidence of an anxiolytic effect. Larger controlled studies incorporating standardised procedures, subject-level analyses, and validated psychological and behavioural outcomes are needed.

KEYWORDS pediatric dentistry; dental anxiety; passive patient-selected music listening; professional dental hygiene; heart rate; nitrous oxide conscious sedation.

INTRODUCTION

Dental fear and anxiety in children remain frequent barriers to routine oral care and may compromise cooperation, prolong chair time, and negatively affect the quality of treatment. Even preventive appointments, which are generally perceived as low-risk, can elicit apprehension when the child anticipates unpleasant sensations, noise, or loss of control [van der Steen et al., 2025; Uggla et al., 2016; Nightingale et al., 2013; Moola et al., 2011; Klassen et al., 2008; Hao et al., 2023; Gan et al., 2025; Paglia, 2023a; Paglia, 2019b]. In particular, professional dental hygiene procedures such as scaling and polishing may trigger discomfort and stress responses, especially in patients with a history of negative dental experiences or high trait anxiety. For paediatric patients, anxiety management is commonly approached through a combination of behavioural strategies and, when necessary, pharmacological support [Crawford et al., 2014; Carr et al., 2012; Bradt et al., 2013b; Bradt et al., 2013a; Bradt et al., 2011; Bradt and Dileo, 2014; Bradt and Teague, 2018; Abd-Elshafy et al., 2015; Aalbers et al., 2017; Crincoli et al., 2020; Dioguardi et al., 2022; Luppieri et al., 2025; Paglia, 2025a; Patano et al., 2023; Saccomanno et al., 2021; Severino et al., 2021a; Oddi et al., 2023]. Inhalation conscious sedation with nitrous oxide/oxygen is an established option in paediatric dentistry for reducing distress and facilitating cooperation, provided that appropriate training, patient selection, and monitoring are ensured [Esposito et al., 2012; Maspero et al., 2019; Gaffuri et al., 2021; Inchingolo et al., 2022b; Inchingolo et al., 2021a; Marinelli et al., 2021]. However, organisational and regulatory constraints may limit its availability in everyday practice and, in some clinical contexts, it may not be routinely applicable during dental hygiene sessions conducted by dental hygienists [van Doornik et al., 2025; van Dessel et al., 2014; Titov et al., 2008; Terrana et al., 2019; Telch et al., 1993; Steenen et al., 2024; Stech et al., 2020]. Consequently, there is strong clinical interest in accessible, low-cost, and non-pharmacological interventions that can be integrated into preventive care without increasing procedural complexity.

Music-based interventions have gained attention as potential adjuncts for anxiety management in both medical and dental settings [Severino et al., 2021b; Patano et al., 2021; Sin and Dennis, 2023; Silveira et al., 2021; Simon et al., 2021; Seligman et al., 2017; Schneider et al., 2005; Sánchez-Meca et al., 2010; Salhi et al., 2022; Zerman et al., 2025; Paglia et al., 2023b; Paglia, 2017; Nagni et al., 2026c; Mummolo et al.,

2019a; Marinelli et al., 2021; Rastelli et al., 2014; Paglia et al., 2023b]. Listening to music may support distraction from aversive stimuli, improve emotional regulation, and enhance a sense of familiarity and control, thereby potentially attenuating autonomic arousal during stressful procedures. In paediatric care, these characteristics are particularly relevant because simple, acceptable, and low-burden interventions are often preferable when the procedure itself is short and pharmacological support is not routinely indicated [Sakol and Power, 1988; Roshanaei-Moghaddam et al., 2011; Rosen et al., 1984; Purohit et al., 2021; Patel et al., 2024; Oosterink et al., 2009; Olatunji et al., 2010; O'Doherty et al., 2023; Ciavarella et al., 2012; Cianci et al., 2020; La Paglia et al., 2025; Lardani et al., 2025; Paglia, 2025b]. Importantly, the approach most easily transferable to everyday dental practice is not formal music therapy delivered by a trained therapist, but rather passive patient-selected music listening, typically delivered through headphones. This distinction is clinically relevant, as patient-selected listening is inexpensive, feasible in routine outpatient settings, and easily integrated into preventive care appointments without increasing procedural complexity or requiring additional personnel [Mitte, 2005; Michalek-Sauberer et al., 2012; Mayo-Wilson and Montgomery, 2013; Mei et al., 2023; Marchand et al., 2009; Mamat et al., 2022; Makieh and Kouchaji, 2025; Ludovichetti et al., 2022; Inchingolo et al., 2026; Dipalma et al., 2025e; Dipalma et al., 2025c]. Professional dental hygiene appointments represent an interesting context in which to test this approach. Although they are non-invasive when compared with restorative or surgical procedures, they may still elicit anticipatory distress, sensory discomfort, and poor cooperation in some children. For this reason, even modest improvements in physiological regulation during hygiene sessions may have practical implications for patient comfort, treatment acceptance, and behavioural management [Paglia, 2026; Lidren et al., 1994; Patano et al., 2021; Kvale et al., 2004; Kusnoto et al., 2025; Kupeli and Gülnahar, 2020; Klingberg and Broberg, 2007; Kim et al., 2024; Janthasila and Keeratisiroj, 2023; Ingersoll et al., 2015; Crincoli et al., 2025; Lo Russo et al., 2018; Paglia, 2020; Malcangi et al., 2023a; Malcangi et al., 2023b; Mummolo et al., 2014; Nagni et al., 2026b; Malchiodi et al., 2025; Botticelli et al., 2021; Candotto et al., 2019]. Physiological parameters may provide objective information on autonomic responses occurring during dental procedures. Among them, heart rate (HR) is practical, non-invasive, and easily recorded in the dental chair. However, HR is influenced by multiple physiological, developmental, behavioural, and contextual factors and should therefore not be considered a direct or validated measure of dental anxiety, fear, distress, or behavioural cooperation [Ihab et al., 2025; Herrera et al., 2018; Hensel et al., 2007; Haug et al., 2012; Harman and Shoemark, 2024; Hakeberg and Berggren, 1993; Paglia, 2021; Colombo and Paglia, 2018]. Accordingly, the aim of this exploratory pilot study was to describe HR changes across predefined procedural phases in paediatric patients undergoing professional dental hygiene with passive patient-selected music listening compared with standard care. In addition, HR patterns were descriptively examined in a small group of patients receiving clinically indicated nitrous oxide/oxygen conscious sedation. The study was intended to generate preliminary physiological data and hypotheses for future controlled investigations incorporating validated psychological and behavioural outcome measures [Celli et al., 1990; Inchingolo et al., 2024a; Paglia et al., 2025c; Paglia et al., 2025a; Paglia, 2024; Braiotta et al., 2023; Nagni et al., 2026a; Nagni et al., 2024; D'Amario et al., 2015; Mancini et al., 2021; Arrigoni et al., 2022; Inchingolo et al., 2012].

MATERIALS AND METHODS

Study design and setting

This single-center pilot study was conducted during the 2023/2024 academic year in a university dental service. The study explored heart rate (HR) trends during professional dental hygiene (scaling and polishing) in paediatric patients managed with standard care, passive patient-selected music listening, or nitrous oxide/oxygen (N_2O/O_2) conscious sedation as a clinically indicated, non-randomised reference condition.

Sample size

As this was an exploratory pilot study, no formal a priori sample size calculation was performed. The sample size was determined by feasibility, based on the availability of eligible paediatric patients during the study period and the limited number of cases with clinical indication for N_2O/O_2 sedation.

Participants

A total of 45 children aged 5–14 years scheduled for a professional dental hygiene session (scaling and polishing) were included. Detailed individual-level baseline demographic and clinical characteristics were not available for the present analysis.

Inclusion criteria

- Age 5–14 years;
- Need for professional dental cleaning (scaling and polishing);
- Sufficient cooperation to tolerate fingertip pulse oximeter placement for HR recordings;
- Written informed consent from parents/legal guardians.

Exclusion criteria

- Unstable cardio-respiratory conditions or contraindications to nitrous oxide sedation;
- Cognitive or behavioural impairments preventing reliable measurement of physiological parameters;
- Refusal by the child or parents/legal guardians to participate;
- Ongoing pharmacological treatment potentially affecting anxiety levels or autonomic/cardiovascular responses;
- History of markedly negative or traumatic dental experiences likely to substantially influence procedural fear or physiological arousal, when documented in the clinical history.

Group allocation

Participants were allocated to three groups:

- Group A – Standard care (control; scaling only); Children underwent the standard hygiene session without any additional intervention.
- Group B – Passive music listening (patient-selected music). Children underwent scaling while listening through headphones to freely selected music according to their preferred genre. Music was played at a comfortable volume throughout the dental hygiene session.
- Group C – N_2O/O_2 inhalation conscious sedation (clinically indicated reference group); Children underwent scaling under N_2O/O_2 inhalation conscious sedation according to Langa's Relative Analgesia technique, with progressive titration of nitrous oxide and continuous monitoring in accordance with current guidelines.

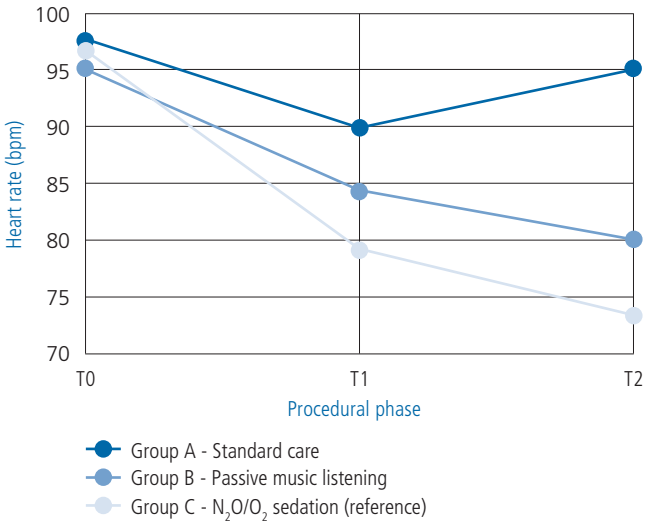


FIG. 1 Mean heart-rate patterns across predefined procedural phases in the three study groups. Mean heart rate (HR, bpm) is shown at baseline (T0), during scaling (T1), and at the end of the session (T2) for Group A (standard care), Group B (passive patient-selected music listening), and Group C (N_2O/O_2 conscious sedation). Group C was clinically selected and non-randomised and is presented exclusively as a descriptive reference group.

Patients in Group C were selected based on clinical indications for sedation (e.g., "special needs" or high anxiety) and were not randomised.

Randomization

Participants eligible for Groups A and B were allocated in a 1:1 ratio by simple randomisation immediately before the procedure. Allocation was determined using a draw method with sealed cards indicating Group A or Group B. Group C was not included in the randomization because N_2O/O_2 conscious sedation was administered exclusively on the basis of clinical indication. Accordingly, Group C was considered a clinically selected, non-randomised descriptive reference group and not a directly comparable randomised study arm.

Outcome measure

The primary outcome was heart rate (HR; beats per minute, bpm), assessed by digital fingertip pulse oximetry. HR was treated exclusively as a descriptive physiological parameter reflecting changes in cardiovascular activity during the procedure. Because HR is influenced by multiple physiological, developmental, behavioural, and contextual factors, it was not considered a direct or validated measure of dental anxiety, fear, distress, or behavioral cooperation. No validated psychometric or behavioral instrument assessing dental anxiety, fear, or cooperation was administered in the present pilot study. Mean HR values and changes in group mean HR were descriptively examined across the three predefined procedural phases.

Data collection procedure

Heart rate was assessed using a digital fingertip pulse oximeter at three predefined procedural time points: T0, with the patient seated in the dental chair before the beginning of the operative procedure; T1, during scaling; and T2, at the end of the session after instrument removal. The available dataset contained HR values recorded at these three standardised procedural time points. Accordingly, the present analysis was based on T0, T1, and T2 values rather than on an analysis of the complete continuous pulse-oximetry trace.

Statistical analysis

Data were analysed descriptively. Heart rate (HR, bpm) values at T0, T1, and T2 were summarised as group means. Absolute changes across procedural time points were reported as differences between group mean values (T1–T0 and T2–T0). Because individual-level data were not available for the present analysis, measures of within-group variability, including standard deviations and interquartile ranges, could not be calculated retrospectively. Accordingly, no formal inferential statistical testing, confidence intervals, or effect size calculations were performed. Given the exploratory nature of the study and the limited sample size, the findings were interpreted descriptively. Group C was clinically selected and non-randomised and was therefore considered exclusively as a descriptive reference group rather than as a directly comparable study arm.

Ethical considerations

The study was conducted in accordance with the Declaration of Helsinki. The study protocol was approved by the local Ethics Committee (protocol code 421; approval date 09/03/2016). Written informed consent was obtained from all parents/legal guardians prior to participation.

RESULTS

A total of 45 children aged 5–14 years undergoing professional dental hygiene (scaling and polishing) were included. Participants were allocated to Group A (standard care; n=19), Group B (passive patient-selected music listening; n=21), and Group C (N_2O/O_2 conscious sedation; n=5), which was a clinically selected, non-randomised reference group. Mean heart rate (HR) values at the three standardised procedural phases are reported in Table 1. In Group A, mean HR decreased from 98.0 bpm at T0 to 90.0 bpm at T1 and was 95.3 bpm at T2. In Group B, mean HR showed a progressive reduction from 95.7 bpm at T0 to 84.5 bpm at T1 and 80.1 bpm at T2. In Group C, mean HR values were 97.6 bpm at T0, 79.2 bpm at T1, and 73.4 bpm at T2. When changes from baseline were considered using differences between mean values, Group A

Group	n	HR T0 (mean)	HR T1 (mean)	HR T2 (mean)	Mean difference (T1–T0)	Mean difference (T2–T0)
Group A – Standard care (control)	19	98.0	90.0	95.3	–8.0	–2.7
Group B – Passive patient-selected music listening	21	95.7	84.5	80.1	–11.2	–15.6
Group C – N_2O/O_2 conscious sedation (reference)	5	97.6	79.2	73.4	–18.4	–24.2

TAB. 1 Descriptive heart-rate values and absolute changes across procedural phases by study group. Mean heart rate (HR, bpm) is reported at baseline (T0), during scaling (T1), and at the end of the session (T2). Absolute changes are expressed as differences between group mean values at T1 and T0 (T1–T0) and between T2 and T0 (T2–T0). Group C (N_2O/O_2 conscious sedation) was clinically selected and non-randomized and is presented exclusively as a descriptive reference group.

showed –8.0 bpm at T1–T0 and –2.7 bpm at T2–T0, whereas Group B showed –11.2 bpm at T1–T0 and –15.6 bpm at T2–T0. The sedation reference group showed mean differences of –18.4 bpm at T1–T0 and –24.2 bpm at T2–T0. These HR trends across the three predefined procedural phases are graphically illustrated in (Figure 1).

Descriptively, Group B showed lower mean HR values than Group A during scaling (T1: 84.5 vs. 90.0 bpm) and at the end of the session (T2: 80.1 vs. 95.3 bpm). The reduction from baseline to the end of the session was –15.6 bpm in Group B and –2.7 bpm in Group A. Group C showed the lowest mean HR values during scaling (79.2 bpm) and at the end of the session (73.4 bpm), whereas its baseline mean HR value (97.6 bpm) was higher than that observed in Group B (95.7 bpm). These observations are descriptive and should not be interpreted as evidence of differences in anxiety, fear, behavioral cooperation, or treatment efficacy (tab. 1).

DISCUSSION

The present exploratory pilot study described HR patterns during professional dental hygiene in paediatric patients managed with standard care, passive patient-selected music listening, or clinically indicated N2O/O2 conscious sedation as a non-randomised reference condition [Guo et al., 2025; Gund et al., 2022; Inchingolo et al., 2024c; Goodwin et al., 2005; Gkinosati et al., 2025; Gillies et al., 2013; Paglia and Colombo, 2025b; Everitt et al., 2019; Dou et al., 2018; Dóro et al., 2017; da definire: 131; Cunningham and Mullaney, 1992; Arcari et al., 2025; Paglia, 2018b; Paglia, 2018a; Paglia, 2019a; Inchingolo et al., 2021b; Inchingolo et al., 2022a; Marchetti et al., 2014; Marchetti et al., 2021; Guerra et al., 2021; Lauritano et al., 2019]. Although HR was recorded continuously throughout the appointment, the descriptive analysis focused on three predefined procedural phases (T0–T2) [Farronato et al., 2020; Farronato et al., 2011; Farronato et al., 2012; Farronato et al., 2013; da definire: 147; Yeh et al., 2024; White et al., 2018; Westen and Morrison, 2001]. This phase-based approach was selected to improve between-subject comparability in a clinical setting in which total chair-time varied among participants and continuous recordings could include transient fluctuations related to movement, communication, or procedural events [Haller et al., 2026; Coventry et al., 2020; Aitken et al., 2002; Albert-Kiszely et al., 2007; Alenezi and Aldokhayel, 2022; AlMoharib et al., 2024]. Mean HR showed different descriptive trajectories across the three groups [Marchetti et al., 2014; Lauritano et al., 2019; van Ballegooijen et al., 2013; Gaffuri et al., 2021; Clark et al., 1999; Paglia and Colombo, 2025a; Bettocchi et al., 2025; Inchingolo et al., 2010b; Inchingolo et al., 2010a; Mummolo et al., 2019b; Ortu et al., 2024; Lombardo et al., 2019]. In Group A, HR decreased from baseline during scaling and subsequently increased toward baseline values at the end of the session. In Group B, mean HR progressively decreased from baseline to the end of the appointment. Group C showed a marked reduction in mean HR during scaling and at the end of the session [Andersson et al., 2012c; Andrews and Williams, 2015; Armfield and Heaton, 2013; Barrera and Norton, 2009; Bayraktar Nahir et al., 2025; Cusenza et al., 2024; Vena et al., 2024; Paglia et al., 2025b; Colombo and Paglia, 2024]. Importantly, these physiological patterns should not be interpreted as direct measures of dental anxiety, fear, distress, or behavioural cooperation, as HR is a non-specific physiological parameter and no validated psychological or behavioural outcome was collected [Dipalma et al., 2025d; Inchingolo et al., 2024b; Lombardo et al., 2020; Muntean et al., 2024; León-López et al., 2022; Jervøe-Storm et al., 2023]. Therefore, the observed differences should be considered preliminary descriptive findings requiring confirmation in adequately powered controlled studies [Andersson et al., 2012a; Andersson et al., 2012b; Andersson et al., 2013; Berger et al., 2009; Berger et al., 2011; Bowler et al., 2012; Roberts et al., 2016; Quail et al., 2020; Inchingolo et al., 2023a; Inchingolo et al., 2023b; Dipalma et al., 2025a].

The clinically indicated N2O/O2 reference group showed the lowest mean HR values during scaling and at the end of the session, but not at baseline. Interpretation of this group requires particular caution because it included only five participants, was clinically selected, and was not randomised [Armfield et al., 2007; Boettcher et al., 2012; Boettcher et al., 2013; Brotman et al., 2007; Çakici and Akkoç, 2025; Chanda and Levitin, 2013]. Patients requiring N2O/O2 may differ systematically from participants in the randomised groups with respect to clinical characteristics, baseline anxiety, previous dental experience, behavioural cooperation, and other factors potentially influencing HR. Accordingly, Group C was included solely to provide a descriptive clinical reference and no direct efficacy comparison with Groups A or B can be inferred from these data [Lo Muzio et al., 2009; Cuijpers et al., 2010; Andrews et al., 2010; Dipalma et al., 2024; Bisson et al., 2013; Ferati et al., 2024; Chen et al., 2020; Coffey et al., 2024; Cohen et al., 2000; Dipalma et al., 2025b; Caliendo et al., 2023; da definire: 210; da definire: 211; Titov et al., 2010; Sälzer et al., 2020; Saccomanno et al., 2012; Saccomanno et al., 2023].

Study limitations

The findings of this exploratory pilot study should be interpreted with caution. First, the overall sample size was limited, particularly in the clinically indicated N2O/O2 reference group, which included only five participants. This group was not randomised and may have differed systematically from the randomised groups because of the clinical indications leading to sedation; therefore, direct comparisons with Groups A and B are not appropriate. Second, HR is a non-specific physiological parameter that may be influenced by age, physical activity, autonomic variability, emotional state, previous experiences, procedural events, and other individual or contextual factors. Consequently, HR cannot be considered a direct measure of dental anxiety, fear, distress, or behavioural cooperation. No validated psychometric or behavioural instrument was administered to assess these outcomes. Third, detailed individual-level baseline demographic and clinical characteristics were not available for between-group comparisons. Therefore, potential confounding related to age, previous dental experience, and other unmeasured baseline characteristics cannot be excluded. Fourth, individual-level HR data were not available for the present analysis. Consequently, measures of within-group variability, including standard deviations and interquartile ranges, could not be calculated retrospectively, and statistical uncertainty and subject-level HR trajectories could not be formally evaluated. Finally, HR was analysed at three predefined procedural time points, and the study was descriptive and exploratory in nature. No formal inferential statistical testing was performed, and no causal or anxiolytic effect of patient-selected music can be inferred from these findings. The results should therefore be considered preliminary and hypothesis-generating and should inform the design of larger controlled studies incorporating detailed baseline characterisation, validated psychological and behavioural outcomes, and subject-level physiological data.

CONCLUSIONS

In this exploratory pilot sample, passive patient-selected music listening was associated with a different descriptive pattern of HR change across the dental hygiene session compared with standard care, including lower mean HR values during scaling and at the end of the session. These findings should not be interpreted as evidence of reduced dental anxiety, fear, distress, or improved behavioural cooperation because HR is a non-specific physiological parameter and no validated psychological or behavioural outcome was collected. The clinically indicated N2O/O2 reference group showed the lowest mean HR values during scaling and at the end of the session; however, this group was small, clinically selected, and non-randomised and was therefore considered only as a descriptive reference. Overall, the present findings are preliminary and hypothesis-generating. Larger controlled studies incorporating detailed baseline characterisation, standardised intervention procedures, subject-level physiological analyses, and validated psychological and behavioural outcome measures are required before conclusions regarding the clinical effects of patient-selected music listening can be drawn.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee (protocol code 421, date of approval 09/03/2016).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

Conceptualisation, A.D.; A.M.I; L.G. and F.C. ; methodology C.M.; L.G.; G.M.(1); G.M.(2) and G.D.I; software L.G; A.D.I.; F.I.; G.D.; C.C. and F.C.; validation, G.D.; C.M. ; A.D.; and .G.M.(1); formal analysis, A.D.I.; A.M.I. ; G.M.(2); G.D.I. and L.G.; investigation, F.C. and A.D.; G.D. and C.M. ; resources, A.D. and F.C. ; data curation, A.M.I.; A.D.I. and F.I.; writing—original draft preparation, L.G., G.M.; C.M.; C.C. and F.C. ; writing review and editing, A.M.I. and G.M.(1); G.M.(2) and A.D; visualization, A.M.I.; G.D.I.; and G.D. ; supervision, L.G.; C.M. and F.C. ; project administration, L.G. and A.M.I; F.I. and G.D. ; All authors have read and agreed to the published version of the manuscript.

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INTRODUCTION

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