Outcomes Assessment in Young Hip Disease

26

Sujith Konan and Fares S. Haddad

Introduction

The term 'outcome' is used in medicine to describe the condition of a patient at the end of therapy or a disease process. The term encompasses a broad spectrum of measures including the degree of wellness and the need for continuing care, medication, support, counseling, or education.

Outcomes Assessment: The Changing Perspective

Historically, the surgeon assessed and reported success or failure of an orthopaedic disease process or operative intervention. While this assessment is extremely valuable, modern day medical practice requires the surgeon to be able to demonstrate outcomes.

Outcome measures or instruments are used to assess the impact of interventions for various purposes such as comparing clinical trials, economic considerations, patient expectations, alternative prostheses, methods' of fixation or surgical techniques. By allowing the comparison between individuals, departments, hospitals and regions with regards to various elements of peri-operative care; outcome assessment enables good practice to be highlighted and propagated, and for remedial action to be instituted where practice is sub-standard.

S. Konan, MRCS
Department of Orthopaedics and Trauma,
Chelsea and Westminster Hospital, London, UK

F.S. Haddad, BSc, MCh (Orth) FRCS (Orth) (✉)
Department of Orthopaedics, Princess Grace Hospital,
Nottingham Place 42, W1U 5NY London, UK

Department of Orthopaedics, The Wellington
Hospital, London, UK

Department of Orthopaedics and Trauma,
University College of London Hospitals, London, UK
e-mail: fsh@fareshaddad.net

Outcome Instruments for the Hip

The study of the properties of outcome instruments is referred to as psychometrics. Outcome instruments use various items such as signs, symptoms, complications, investigations or aspirations as a measure of a dimension. Broadly, all outcome instruments may be classified into two categories. The item measure of a dimension may be the patient's own perception or 'subjective'. If the measure is the result of an observation made by an examiner or device or investigation, it is termed 'objective' data.

Outcome assessment in young hip disease may be performed in several ways such as morbidity from the hip pathology, morbidity following surgical intervention, incidence of specific complications after surgical intervention (e.g.: dislocation rate following hip replacement). Health related quality of life from the disease or surgical intervention, radiological outcomes; in patient hospital stay etc are examples of non-generic outcome tools.

Questionnaires are often used to document various items of measure, which may then be expressed as scores for the purpose of documentation and comparison. Well-designed self-reported questionnaires with or without measurement and physical assessment are currently the most useful outcome tools used for the young hip disease. In addition to this and specifically for the younger patient, motion analysis, kinematic assessment, dynamometers and performance battery tests are useful and sensitive measures of detecting change in outcome. When measuring outcome of rehabilitation following muscle injury or surgical reconstruction of muscles acting on the hip joint, various muscle specific strength testing scores and devices are also available. This chapter discusses the various outcome assessment tools relevant for young hip disease.

Questionnaires

Questionnaires document responses to specific objective or subjective measures that are then expressed collectively as a score. Responses may be constructed as binary (1/2 or yes/no)

F.S. Haddad (ed.), *The Young Adult Hip in Sport*,
DOI 10.1007/978-1-4471-5412-9_26, © Springer-Verlag London 2014

or graded. For graded or scaled responses, visual analogue scales (VAS), Likert scales or some form of adjectival questions are used. In general, questionnaires should be acceptable to patients, simple, easy to use and score, and preferably concise.

The assessments made by questionnaires may be generic, disease-specific, joint-specific or patient specific.

Generic surveys: Assess any medical or surgical intervention and investigate all aspects of quality of life.

Disease specific: Disability relating to a particular condition or single disease entity. Joint specific: Impact of disease in one particular joint.

Patient specific: Currently experimental tool. In this method, the focus is shifted from a group level to an individual level and each patient is classified as a responder or a non-responder (the responder criteria) to a particular intervention; or whether a certain level of low symptom severity is attained (the state-attainment criteria)

Outcome questionnaire tools are often designed for specific populations. The outcome tools tested have to be established as a valid and reliable instrument. An outcome measure must be easy to administer and regular feedback of aggregated results encourages compliance.

Validation of an outcome tool involves testing various criteria [1, 2]. These are briefly discussed below

Redundancy: Refers to whether one or more items of a questionnaire correlate with each other. May be measured using Cronbach's alpha (values between 0.7 and 0.9).

Internal consistency: Refers to the homogeneity of the items in the tool

Agreement: Refers to how close scores are for repeated measurements

Reliability: Refers to how well the measurement can distinguish persons from each other despite measurement errors. Internal consistency determines whether a survey measures a single variable. Reproducibility investigates if a questionnaire produces the same results if repeated under the same conditions. Interobserver reliability (agreement between two or more observers on the same occasion), intra-observer reliability (same observer on separate occasions), and test-retest reliability (stability of the measure over time in the same subject) are all aspects of reproducibility.

Responsiveness: Refers to how well an instrument can detect clinically important changes over time.

Floor and Ceiling effects: Number of respondents with the lowest or highest possible score. 'Floor' effect refers to the situation where a questionnaire is unable to measure a negative value that is lower than the range provided in the choice of answers. 'Ceiling' effect refers to the situation where a questionnaire is unable to measure a positive value that is higher than the range provided in the choice of answers.

Interpretability: The degree to which qualitative meaning can be assigned to quantitative scores.

Validity: Face and content validity assess whether a survey fully investigates the intended topic of interest. Content validity examines the ability of the instrument to measure all aspects of the condition for which it was designed so that it is applicable to all patients with that condition. Criterion validity refers to the extent to which scores on the tool relate to a gold standard. Construct validity refers to the degree to which scores on the tool relate to other measures in a manner consistent with theoretically derived hypotheses concerning the domains being studied.

Various questionnaire based outcome measures are currently used for assessment of young adult hip. They were traditionally developed for the general population and often the older patient but have been used in the younger adult for lack of specific outcome tools aimed at the higher demand patient. Hence, their ability to discriminate the higher demand individual and improved functional outcome in the hip joint is often questioned. These outcome questionnaires may be disease specific, joint specific or generic and continue to provide a tool to document and compare outcomes following surgical intervention to the hip joint. A brief summary of the various commonly used hip scoring systems [3, 4] with their strengths and weaknesses are discussed below.

The Hip Outcome Scores (HOS) [5]

It is a self-reported functional status instrument. Twenty items are tested using two subscales, the activities-of-daily-living (ADL; 19 items) and sports subscales (9 items). Each item has six potential responses, ranging from "unable to do" to "no difficulty," and a response of "nonapplicable". The ADL and Sports subscales are scored separately. The item score total is divided by the highest potential score and multiplied by 100 to get a percentage.

Strengths: Developed as a tool to measure higher demand activities. It has shown strong test-retest reliability and responsiveness.

Weaknesses: No long-term outcome studies have documented the usefulness of this outcome measure.

Non-arthritic Hip Score (NAHS) [6]

It was developed to measure preoperative and postoperative hip pain and function in 20- to 40-year-old patients with hip pain without obvious radiographic diagnosis. It is self-administered and symptom-related only, requiring no physical examination. The scoring system includes 20 multiple choice questions each having five responses. Values are added at the end and multiplied by 1.25 to arrive at a final score. The maximum score is 100 indicating normal hip function. This score is divided into four domains: pain, mechanical symptoms, physical function, and level of activity. All ten questions measuring pain and physical function come directly from the Western Ontario and McMaster Universities Osteoarthritis Index. Four additional questions deal exclusively with mechanical symptoms involving the hip. The fourth set of questions measures activity level. This scoring scheme is aimed at The Strengths: It is self-administered and all of the questions are weighted equally. It is reproducible, internally consistent, valid, responsive to clinical change and has moderate construct validity.

Weaknesses: There are no long term studies documenting its usefulness.

The Hip Disability and Osteoarthritis Outcome Score (HOOS) [7, 8]

A joint-specific survey, which has 40 questions, each of which has five possible answers (scored 0–4). The questions can be grouped into five higher order dimensions: pain, other symptoms, activities of daily living, sport and hip-related quality of life. The scores from each dimension are added together and then transformed onto a scale of 0–100 (100 = best outcome).

Strengths: It valid and responsive. It contains all the WOMAC Likert 3.0 questions.

Weaknesses: It is based on self-report of functional status and performance and this may be a disadvantage when comparing with instruments which have objective instruments.

The University of California at Los Angeles Hip Scale (UCLA) [9]

It is often used to assess post-operative outcome in arthroplasty patients and more recently, to assess hip arthroscopy outcomes. The scale explores four dimensions: pain, walking, function and activity. There are ten points on the scale (ten indicating best outcome).

Strengths: Measures activity level and this gives important qualitative information regarding outcome.

Weaknesses: There is no published psychometric evidence validating the UCLA hip scale.

Merle d'Aubigne and Postel Score [10]

Developed in 1949. Pain, mobility & the ability to walk are scored from 0 to 6, with 0 being the worst and 6 the best. The scores are added together to reach the overall score (out of 18). In 1954, in the mobility section, "can tie shoelaces" was changed to "can reach his foot". Since then, it is referred to as the modified Merle d'Aubigne and Postel score.

Strengths: Simple and easy to apply.

Weakness: Not been validated. Ambiguity between grade 4 (mild walking pain) and grade 5 (mild & inconstant) may result in incorrect scores or make scores not comparable. A clinician examines the mobility section, introducing the possibility of clinician bias. A ceiling effect is noted with this scoring system.

The Charnley Score [11]

A modification of the Merle d'Aubigne and Postel score (developed in 1972). It grades hip pain, mobility and walking on a scale of 0–6. The scores are not combined like in the Merle d'Aubigne and Postel scoring system.

Strengths: Simple to perform, reproducible and easy to apply. Has been validated.

Weaknesses: There is no psychometric testing of the Charnley score supporting its use. As the assessment is entirely performed by the surgeon there is potential to introduce a clinician bias.

Harris Hip Score (HHS) [12]

Developed in 1969 to assess outcomes following total hip arthroplasty. It is a multi-dimensional observational assessment, which contains eight items representing pain, walking function, activities of daily living, and a physical examination- range of motion of the hip joint. The questions are split into three categories: pain (0–44 points), function (0–47 points) and level of activity. Assessment of the functional component is based on the presence of a limp, the use of walking aids, and specified activities. The scores from each section are added together (maximum 100), with a score of 90–100 rated as excellent, 80–90 good, 70–79 fair, 60–69 poor, and less than 60 as failed result.

Strengths: It is able to detect changes in hip function. It is an observational assessment, thus eliminating patient bias. It has been shown to have high validity and reliability.

Weaknesses: It does not account for individual differences in age, health or personal issues that may impact the score. It is an objective interpretation by a subjective individual, and therefore could lead to bias.

Oxford Hip Score (OHS) [13]

A joint specific patient-centred outcome measure that was devised in 1996. The OHS is designed to assess pain and functional ability from the patient's perspective. It consists of 12 questions rated from 1 to 5 (1 representing best outcome and 5 worst). The 12 individual scores are added together to formulate the overall score ranging from 12 to 60

(12 = best outcome). In the revised OHS, each question is scored from 0 to 4, with 4 indicating the best outcome and overall score range from 0 to 48 (48 = best outcome).

Strengths: It is easy to use and can be completed by patients independent of clinicians. It has high responsiveness; is highly sensitive to change in patients undergoing hip arthroplasty; is internally consistent; reproducible; and achieves a high follow-up rate.

Weaknesses: Certain questions lack clarity or are irrelevant and are difficult for respondents to answer. Patient factors such, as co-morbidities are not taken into account. It tries to categorise pain into a single category, which is not always possible

Disease-Specific Quality-of-Life Outcome Measures

The Arthritis Impact Measurement Scale and the Western Ontario and McMaster University Osteoarthritis Index (WOMAC) are two commonly used disease specific quality-of life outcome measures which may be used to assess young hip outcome.

The Western Ontario and McMaster University Osteoarthritis Index (WOMAC) [14]

It is a self-administered disease-specific health status measure for osteoarthritis (hip and knee joint). Three categories: pain (5 questions), stiffness (2 questions) and physical function (17 questions) are tested. Individual question responses are assigned a score of between 0 (extreme) and 4 (none). Individual scores are summed to form a raw score ranging from 0 (worst) to 96 (best). Scores are normalised by multiplying each score by 100/96. This produces a reported WOMAC score of between 0 (worst) and 100 (best).

Strengths: It is valid, reliable and sensitive to change.

Weaknesses: The scores lack specificity and may be influenced by factors such as arthritis in other joints, fatigue, depression, regional back pain and psychological status. Large sample sizes and robust statistical tools are required to demonstrate significance differences in mean scores.

A modified 12-item WOMAC Osteoarthritis Index has also been developed specifically for femoroacetabular impingement (FAI).

Arthritis Impact Measurement Scale (AIMS) [15]

It measures the health status of patients with rheumatic diseases. The 80 questions are split into the subscales: mobility, physical activity, dexterity, household activity, social activity, activities' of daily living, pain, depression and anxiety.

Strengths: It is reliable, valid and sensitive to change.

Weaknesses: Cultural differences have been noted between the Swedish and American patients.

Short-Term Clinical Outcome Measures

They are commonly used to report the clinical impact of operative intervention and the physiological effect of surgery. The Post-Operative Morbidity Survey (POMS) [16] has been used in post-operative morbidity, outcomes and effectiveness research and has been shown to be reliable, valid and acceptable to patients. Other less reliable tools are the event rates, the mortality rate and length of hospital stay.

Generic Quality of Life (QOL) Outcome Measures

They assess overall health-related quality of life and are not specific to age, disease or treatment group. QOL is defined (Testa and Simonson) [17] as 'the physical, psychological, and social domains of health, seen as distinct areas that are influenced by a person's experiences, beliefs, expectations, and perceptions.' The World Health Organisation Quality of Life Group recommended that generic surveys should explore five areas: physical health, psychological health, social relationship perceptions, function and well-being. Commonly used generic outcome measures are: the Medical Outcomes Study 36-Item Short Form Health Survey (SF-36), the Medical Outcomes Study 12-Item Short Form Health Survey (SF-12), the European quality-of-life five dimension questionnaire (EuroQol/EQ-5D).

The Medical Outcomes Study 36-Item Short Form Health Survey (SF-36) [18]

It SF-36 is a multi-purpose questionnaire available in American English as well as United Kingdom English. It refers to health over the previous 4 weeks but a more acute version, referring to health over the previous week, is available. The questionnaire contains 36 questions, each of which has between 2 and 6 answers. Each is scored between 0 (poor health) and 100 (good health). The questions are grouped into one of eight health domains: bodily pain (BP), physical functioning (PF), role limitations due to physical health (RP), general health (GH), mental health (MH), vitality (VT), social functioning (SF) and role limitations due to emotional health (RE). It also has a health transition question does not contribute to any of the eight domains. The domains can be amalgamated into two higher order groups, known as the Physical Component Summary (PCS) and the Mental Component Summary (MCS). The PCS is calculated from the BP, PF, RP and GH scores and is most responsive to treatments that alter physical symptoms. MCS is calculated from the MH, VT, SF and RE scores and is most responsive to drugs and therapies that target psychiatric disorders. Three of the scales (VT, GH and SF) have a significant correlation with both the physical and mental summary measures.

Strengths: It is suitable for self-administration, computerized administration or administration by an interviewer either in person or by telephone. It is valid, reliable, sensitive and acceptable to patients. It has been used in over 4,000 publications assessing over 200 different diseases.

Weaknesses: It has 'floor' and 'ceiling' effects.

The Medical Outcomes Study 12-Item Short Form Health Survey (SF-12) [19]

It is an abridged version of SF-36 with 12 out of the 36 questions which can be amalgamated to produce profiles of the eight SF-36 health concepts but only if the sample size is sufficiently large. The scores are calculated using weighted algorithms for which a computer program is available.

Strengths: It is shorter and quicker for patients to complete and quicker for research personnel to record and analyse data.

Weaknesses: A computer program is necessary for scoring each survey. It has less construct validity and sensitivity than SF-36 producing less precise scores for the 8-scale health profile. This could result in insignificant findings in smaller studies.

The European Quality of Life 5 Dimension Questionnaire (EuroQol/EQ-5D) [20]

It has 15 questions regarding five aspects of general health: mobility, self-care, usual activities, pain and depression. Each question has three possible answers: 'no problem', 'moderate problem' or 'extreme problem'. It also has a visual analogue scale for the patients' assessment of their overall health (0 = worst possible health; 100 = best possible health).

Strengths: It is self-administered, easy to complete and is valid and reliable.

Weaknesses: It suffers from ceiling' effects. There is limited psychometric analysis of the questionnaire.

Motion Analysis [21, 22]

Functional outcome can be assessed using carefully planned questionnaire outcome tools that incorporate subjective and objective tasks. Another reliable method of quantifying function in a joint is by the use of motion analysis. Although it is still widely available as a research tool, motion analysis may be a useful in the outcome assessment of the young adult hip. Subjective outcome questionnaires may not discriminate young adults who maintain high levels of physical function despite pain and muscular weakness. Motion analysis enables kinematic and kinetic data to be obtained. This and can be used to quantify movement patterns and provide reliable outcome tools following open or arthroscopic impingement surgery, osteotomy or replacement arthroplasty. Motion analysis has the advantages of being able to detect force transmission across joints, and subtle improvements or limitations in joint function. Motion analysis has a variety of other applications, such as athletic performance analysis, surveillance, man–machine interfaces, content-based image storage and retrieval, and video conferencing. The process of interpreting human motion involves motion analysis of body parts; tracking movements with multiple camera perspectives; and recognizing human activities from image sequences.

Gait analysis has been used to assess quality of post-operative gait. Using healthy subjects as controls, and by carefully matching variables such as age, height, weight and gender the role of surgical intervention in restoring normal gait and joint reaction forces may be assessed. Also, by repeating analysis at various time points, it is possible to study the long-term effects of surgical intervention in maintaining normal hip biomechanics. Using gait analysis, various authors have demonstrated increased spatio-temporal and kinematic outcomes following arthroplasty. Long-term follow up has shown further improvement, suggesting that optimal functional improvement may occur over longer periods. Data also suggests that hip function and gait may not return to the same level as for a healthy control group following arthroplasty. Motion analysis has also been used to compare results of arthroplasty versus resurfacing with some studies showing similar outcomes for restoring kinematics while others noticing improved kinematics and abductor function with resurfacing arthroplasty. The effect of post-operative rehabilitation regimes may also be compared.

Motion analysis has been used to compare outcomes of different surgical approaches to the hip joint. A faster recovery has been noted only in the immediate stages after an anterior approach, probably because the hip abductors are spared. Once the abductors have healed, no difference is seen between anterior, anterolateral or posterolateral approaches. Outcomes were also not different when minimally invasive approaches were used instead of standard length incisions.

In the outcome assessment of young adult hip, motion analysis enables subtle functional limitations to be detected. This may not be possible using conventional questionnaire based outcome tools. While motion analysis may be less

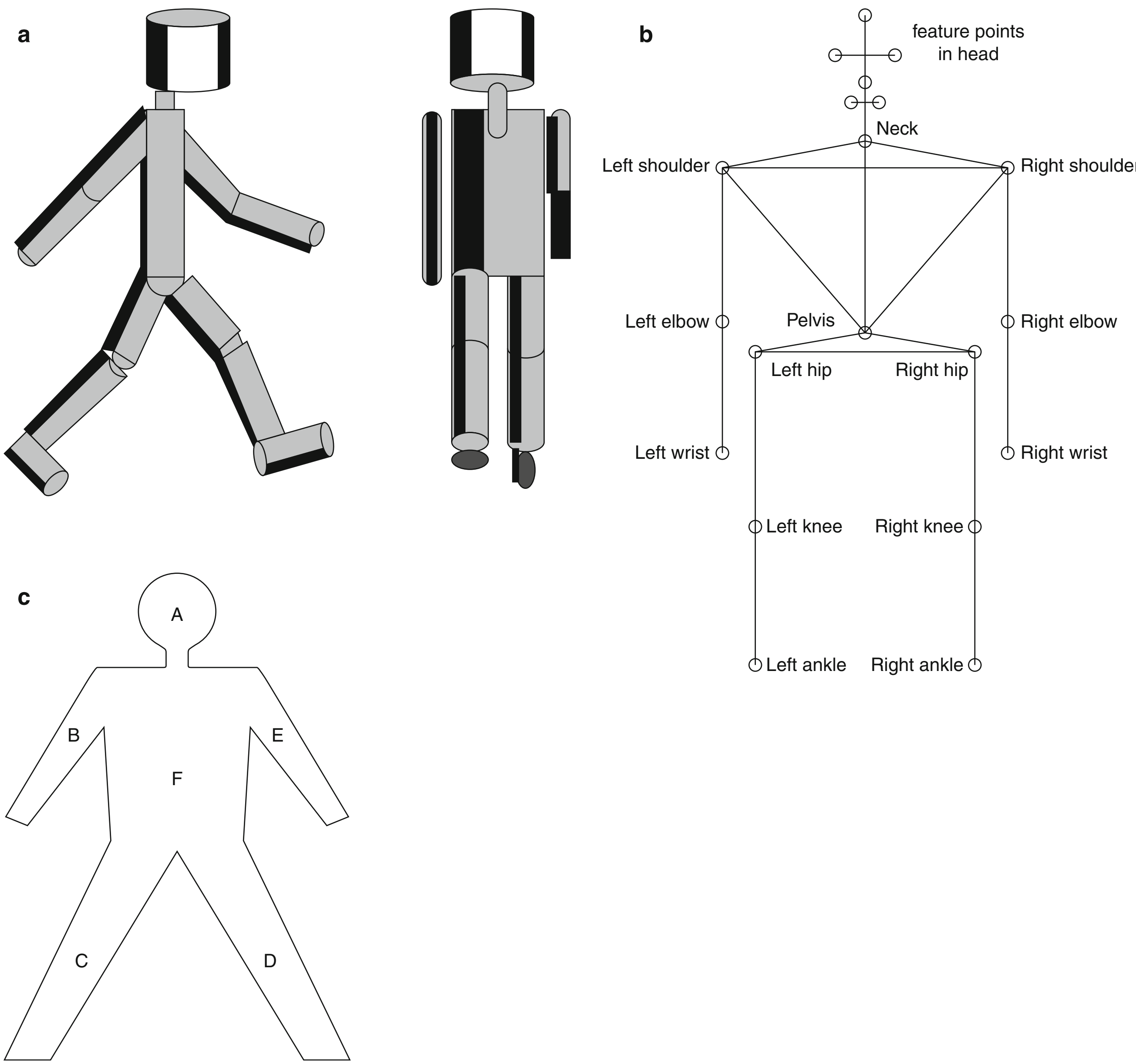

Fig. 26.1 (**a**, **b** and **c**) Figures illustrate one, two and three dimensional motion analysis model. Three-dimensional gait analysis (3DGA) and gait summary measures can be used to quantify the degree of gait deviation from normal, stratify severity, document changes in gait over time and evaluate interventions (Reprinted from Aggarwal and Cai [21] with permission)

necessary in the older adult undergoing routine hip surgery; the younger high demand adult and especially the elite athlete requiring focused rehabilitation would benefit from precise kinematic outcome assessment. Rehabilitation following prosthetic lower limb reconstruction, hip arthroscopy, periacetabular osteotomy, corrective femoral osteotomy and comparison of different types of arthroplasty are some of the other examples where motion analysis based outcome tools may be preferred.

Three-dimensional gait analysis (3DGA) and gait summary measures (obtained by applying data reduction techniques to gait dynamic data) can be used to quantify the degree of gait deviation from normal, stratify severity, document changes in gait over time and evaluate interventions. Figure 26.1a, b, c illustrate one, two and three dimensional motion analysis model. This has mainly been used in cerebral palsy and amputees but its use may be extended for other indications in future. Gait summary measures may be based on instantaneous values like the Gillette Gait Index (GGI) or may utilise the entire waveform as in the Gait Deviation Index (GDI) and the Gait Profile Score (GPS). The Movement Analysis Profile (MAP) elucidates underlying causes of gait deviation by calculating a score for individual kinematic variables.

Performance Based Assessments [23–25]

Self-reports of physical function reflect the ability of patients to do activities, as well as what patients experience during the activities (e.g., pain, exertion). This limits the ability of self-reports of physical function to accurately represent functional outcome.

Detailed assessment and evaluation of physical activity requires the measurement of the mechanical load of activities on the hips, the frequency and duration of recreational activities and the measurement of load cycles. Physical activity monitors, such as pedometers and accelerometers can quantify physical activity. Very few studies have validated a pedometer in hip pathology. Pedometers differ in their validity. Accelerometers may be more suitable because they can also give an indication of the intensity of the activity, which is an important factor in wear production. Accelerometers may also be suitable for etiological and prognostic studies, alone or in combination with questionnaires. They however, have limited ability to measure cycling and swimming.

We have developed and validated a discriminating functional hip [26] score in our institution for use in patients with hip disability that could be used to demonstrate functional improvement in the younger, high demand adult patient. The functional hip score tests five tasks; single leg stance; timed stair climb; lateral step up onto stairs; three forward jumps, standing up between jumps; three sideways jumps. Each task is scored on a mutually exclusive scale of four choices that are ordered in the same hierarchical arrangement for all tests. For each task, the patient also grades the pain associated with performing the test and the difficulty of performing the task, respectively, on a scale of 1–10. A value of 10 represents inability to perform the given task. All scores from the tasks were recorded and used unweighted to avoid any preconceived bias by the person interpreting the results. The final results of the functional hip score are calculated and interpreted as sets of three; function (F), pain (P), and difficulty (D). Our functional hip score has been validated against WOMAC and SF-36 scores and shows good reliability, high internal consistency and lack of floor and ceiling effects.

Radiographs, Computerised Tomograms (CT) and Magnetic Resonance Imaging (MRI)

CT and MRI are commonly used in the diagnosis and preoperative planning of young adult hip pathology. Serial follow up imaging is useful to monitor progression of the pathology and to evaluate post-operative results. They provide valuable tools for outcome assessment of the young hip. Their role as validated outcome tools is yet to be established. Plain Radiographs provide essential information to diagnose and treat musculoskeletal disorders. However, while radiographic classification systems and numerous radiographic parameters have been reported, their reliability remains unclear. Various factors such a patient positioning on table, distance of the patient from the X-ray source and film, body habitus, rotation and deformities of the bone or joint may all influence the standardisation of radiographs. When factored in with other aspects of the patient presentation and physical examination, the diagnostic reliability is improved. The diagnosis and treatment of prearthritic and early arthritic hip disease is an area of intense interest. Despite limitations, radiographic parameters may be used as objective outcome tools by clinicians in pre-arthritic hip conditions and long term follow up. Some of the commonly used plain radiographic parameters are summarised.

Assessments Made on Anteroposterior Radiographs of the Pelvis [27]

Acetabular depth: The relationship of the floor of the acetabular fossa and the femoral head in relation to the ilioischial line. In a "profunda" hip, the floor of the acetabular fossa is tangential or medial to the ilioischial line. In a "protrusio" hip, the medial edge of the femoral head is medial to the ilioischial line. Profunda and protrusion increase risk for pincer impingement.

Acetabular inclination (Tonnis angle): Normal 0 to 10°. The angle formed between the horizontal line running through the most inferior point of the sclerotic acetabular sourcil and a line extending from the most inferior point of the sclerotic acetabular sourcil to the lateral margin of the acetabular sourcil. Hips with an increased Tonnis angle may be at risk for structural instability, and those having a decreased angle for pincer impingement.

Acetabular version: Hips are normally anteverted. In retroverted hips, the anterior wall crosses the posterior wall of the acetabulum before reaching the lateral aspect of the sourcil ("crossover sign"). Errors may occur due to pelvic tilt and/or malrotation. Retroverted hips are at risk for pincer impingement.

Hip center: The hip center is considered lateralized if the medial aspect of the femoral head is greater than 10 mm from the ilioischial line and not lateralized if the medial aspect of the femoral head is less than 10 mm from the ilioischial line. Lateralized femoral heads were considered to be a sign of structural instability or dysplasia.

Congruency: Degree of conformity between the femoral head and acetabulum. Incongruent hips may be a result of dysplasia or impingement.

Pelvic tilt/rotation: The obturator foramina should appear symmetric if the pelvis radiograph is not rotated. In the absence of pelvis tilt on the radiograph, the distance from the tip of the coccyx to the superior aspect of the symphysis pubis should measure 1–3 cm.

Assessments made on anteroposterior, frog-lateral and crosstable lateral radiographs of the pelvis.

Head sphericity: Suggested by the femoral epiphysis extending beyond the margin of the reference circle. Hips with an aspherical head may be at risk for impingement.

Head-neck offset: The anterior and posterior femoral head-neck junction may be at risk of impingement in the presence of convexity or when there is decreased concavity.

Tonnis grade: This classification system grades osteoarthritis from 0 to 3

Grade 0: no signs of osteoarthritis.

Grade 1: increased sclerosis of the head and acetabulum, slight joint space narrowing, and slight lipping at the joint margins.

Grade 2: small cysts in the head or acetabulum, moderate joint space narrowing, and moderate loss of sphericity of the head

Grade 3: large cysts in the head or acetabulum, joint space obliteration or severe joint space narrowing, severe deformity of the femoral head, or evidence of necrosis.

Muscle Strength Assessment [28–30]

Impairments in muscle strength and range of movements are important correlates of physical function and useful outcome measures in research and clinical settings. Objective measurement of muscle strength provides important clinical information about weakness that may relate to functional limitations. It was traditionally used for serial assessment following neurological injuries. Increasingly, it has become necessary to assess muscle strength during the rehabilitation of muscular or musculo-tendinous tears; following surgical repair or reconstruction of tendon avulsions (e.g.: proximal hamstring tendon) or for testing athletes during pre-participation sports physical examination. Figure 26.2a, b show muscle testing of specific hip muscle groups using purpose made devices.

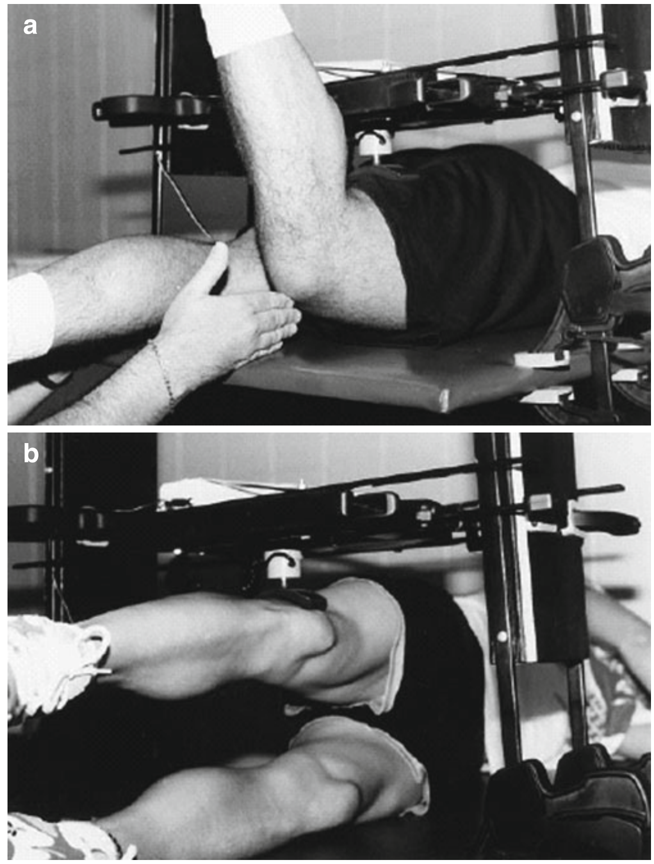

Fig. 26.2 (**a** and **b**) Figures illustrate muscle testing of specific hip muscle groups using purpose made devices. It may be useful to assess muscle strength during the rehabilitation of muscular or musculo-tendinous tears; following surgical repair or reconstruction of tendon avulsions (e.g. proximal hamstring tendon) or for testing athletes during pre-participation sports physical examination (Reprinted from Nadler et al. [29] with permission)

Manual muscle testing (MMT): It is the most common method used for assessing muscle strength. It is easy to perform at the bedside, does not require any special equipment and subjectively grades muscle strength on a 5-point scale. This method of muscle strength testing cannot detect small to moderate strength changes. It is also unsuitable when used to follow up subtle loss of muscle strength (e.g.: scores of four and higher).

Handheld dynamometer (HHD): They provide better objective analysis of muscle strength compared to MMT and can detect small differences in muscle strength than MMT. They are portable, simple, user friendly, and comparatively inexpensive. The downside is that they provide only limited information, such as peak force, time-to-peak force, and total test duration. In order to use the HHDs, the examiner has to stabilise the limb. Hence, differences may be seen in readings between different examiners. Stronger forces requiring capable of producing greater forces are also more difficult to assess using HHDs. They are not capable of generating strength curve profiles or power output estimates. They also do not provide positional information on the limb or joint at which strength was tested.

The Dynamometer Anchoring Station (DAS), is a portable device incorporating an HHD fixed into a platform. This provides the advantage of portability, low cost, ease of measurement and lack of reliability on tester strength especially for the lower limb musculature.

Stationary isokinetic dynamometers (e.g.: the Cybex II). This type of dynamometer provides better stabilization for the patient during testing. Isokinetic machines are considered the criterion standard and provide multiple parameters, such as peak force, endurance, power, and angle of maximal force, occurrence and generate strength curves. They are ideal for hip and thigh musculature. They yield highly reliable strength measurements, but are expensive, not portable and not really designed for routine clinical examinations.

Manual muscle tester system: Some devices have been described that combine force transducer; motion sensor; and a computer. A hand grip or a force pad is used to apply a consistent force directed towards the transducer. The MMT system appears to be a valid and reliable device suitable for clinical manual muscle strength testing. The motion and position device distinguishes the manual muscle tester from other hand-held dynamometers and assure consistent and standardized limb positioning, as well as repeatability. Drawbacks of this system are the issue of the strength and skill of the clinician doing the assessment and the variability noted with the testing protocol, the joint position, the time of day, the type of verbal encouragement and motivation, and the number of examiners doing the strength assessments. Also, some muscle groups are known to give more repeatable results.

Conclusion

Management of young adult hip disorders is an emerging speciality. Advancement in understanding of the precursors of hip osteoarthritis, better techniques of osteotomy, development of hip arthroscopy and emerging techniques of repairing muscle avulsions have all contributed to the surge in surgical management of the young adult hip pathology. Unlike the elderly population, the outcome measures used for assessing the younger adult have to address the higher functional demands and expectations of the patients. Currently, questionnaire based documentation of improvement in pain, function and disability is the most widely available outcome measure. There is a need for development of function based outcome measures that can discriminate high level hip function. Currently radiological tools, gait analysis, dynamometers and motion sensors are widely researched for use in measuring hip function but lack availability, reproducibility and reliability. Future studies may aim at amalgamating various questionnaires, performance tasks and gait and motion sensor tools to develop ideal functional outcome tool. It may also be necessary to develop disease specific or procedure specific outcome measures to demonstrate improvement following surgical intervention.

References

1. Terwee C, Bot S, de Boer M, van der Windt D, Knol D, Dekker J, Bouter L, de Vet H. Quality criteria were proposed for measurement properties of health status questionnaires. J Clin Epidemiol. 2007;60:34–42.
2. Scientific Advisory Committee of the Medical Outcomes Trust. Assessing health status and quality-of-life instruments: attributes and review criteria. Qual Life Res. 2002;11:193–205.
3. Ashby E, Grocott MP, Haddad FS. Outcome measures for orthopaedic interventions on the hip. J Bone Joint Surg Br. 2008;90(5):545–9.
4. Ahmad MA, Xypnitos FN, Giannoudis PV. Measuring hip outcomes: common scales and checklists. Injury. 2011;42(3):259–64. Epub 2010 Dec 15. Review.
5. Martin RL, Kelly BT, Philippon MJ. Evidence of validity for the hip outcome score. Arthroscopy. 2006;22(12):1304–11.
6. Christensen CP, Althausen PL, Mittleman MA, Lee JA, McCarthy JC. The nonarthritic hip score: reliable and validated. Clin Orthop Relat Res. 2003;406:75–83.
7. de Groot I, Reijman M, Terwee C, Bierma-Zeinstra S, Favejee M, Roos E, et al. Validation of the Dutch version of the Hip disability and Osteoarthritis Outcome Score. Osteoarthr Cartil. 2007;15: 104–9.
8. Nilsdotter A, Lohmander L, Klassbo M, Roos E. Hip disability and osteoarthritis outcome score (HOOS) – validity and responsiveness in total hip replacement. BMC Musculoskelet Disord. 2003;[electronic resource] 4:10.
9. Amstutz HC, Thomas BJ, Jinnah R, Kim W, Yale C. Treatment of primary osteoarthritis of the hip. A comparison of total joint and surface replacement arthroplasty. J Bone Joint Surg Am. 1984;66: 228–41.
10. Merle d'Aubigne R, Postel M. Functional results of hip arthroplasty with acrylic prosthesis. J Bone Joint Surg Am. 1954;36:451–75.
11. Charnley J. Long term results of low friction arthroplasty of the hip performed as a primary intervention. J Bone Joint Surg Br. 1972;54: 61–76.
12. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am. 1969;51(4):737–55.
13. Dawson J, Fitzpatrick R, Carr A, Murray D. Questionnaire on the perceptions of patients about total hip replacement. J Bone Joint Surg Br. 1996;78(2):185–90.
14. Bellamy N, Buchanan WW, Goldsmith CH, et al. Validation study of WOMAC: a health status instrument for measuring clinically-important patient-relevant outcomes following total hip or knee arthroplasty in osteoarthritis. J Orthop Rheumatol. 1988;1:95–108.
15. Meenan RF, Mason JH, Anderson JJ, et al. AIMS2. The content and properties of a revised and expanded Arthritis Impact Measurement Scales Health Status Questionnaire. Arthritis Rheum. 1992;35: 1–10.
16. Bennett Guerrero E, Welsby I, Dunn TJ, et al. The use of a postoperative morbidity survey to evaluate patients with prolonged hospitalization after routine, moderate-risk, elective surgery. Anesth Analg. 1999;89:514–9.
17. Testa MA, Simonson DC. Assessment of quality-of-life outcomes. N Engl J Med. 1996;334(13):835–40.
18. Ware JE, Kosinski M, Gandek B. SF-36 health survey: manual and interpretation guide. 2000th ed. Lincoln: Quality Metric Inc; 1993.
19. Jr Ware JE, Konsinski M, Keller SD. A 12-item short-form health survey: construction of scales and preliminary tests of reliability and validity. Med Care. 1996;34:220–33.
20. EuroQol—a new facility for the measurement of health-related quality of life. The EuroQol Group. Health Policy. 1990;16(3):199–208.
21. Aggarwal JK, Cai Q. Human motion analysis: a review. In: Computer vision and image understanding: CVIU, vol. 73(3). Orlando: Academic; 1999. p. 428–40.
22. Sinha A, Twycross-Lewis R, Small C, Morrissey D, Maffulli N. Motion analysis as an outcome measure for hip arthroplasty. Surgeon. 2011;9(5):284–91. Epub 2011 Mar 13.
23. Stratford PW, Kennedy DM. Performance measures were necessary to obtain a complete picture of osteoarthritic patients. J Clin Epidemiol. 2006;59:160e7.
24. Kennedy DM, Stratford PW, Wessel J, Gollish JD, Penney D. Assessing stability and change of four performance measures: a longitudinal study evaluating outcome following total hip and knee arthroplasty. BMC Musculoskelet Disord. 2005;6:3.
25. Stratford PW, Kennedy DM, Riddle DL. New study design evaluated the validity of measures to assess change after hip or knee arthroplasty. J Clin Epidemiol. 2009;62:347–52.

26. Konan S, Tahamassebi J, Haddad FS. Development & validation of a discriminating functional hip score. HSS Journal 2012;(8) 1556–3316.
27. Clohisy JC, Carlisle JC, Trousdale R, Kim YJ, Beaule PE, Morgan P, Steger-May K, Schoenecker PL, Millis M. Radiographic evaluation of the hip has limited reliability. Clin Orthop Relat Res. 2009;467(3):666–75. Epub 2008 Dec 2.
28. Scott DA, Bond EQ, Sisto SA, Nadler SF. The intra- and interrater reliability of hip muscle strength assessments using a handheld versus a portable dynamometer anchoring station. Arch Phys Med Rehabil. 2004;85(4):598–603.
29. Nadler SF, DePrince ML, Hauesien N, Malanga GA, Stitik TP, Price E. Portable dynamometer anchoring station for measuring strength of the hip extensors and abductors. Arch Phys Med Rehabil. 2000;81(8):1072–6.
30. Pua YH, Wrigley TV, Cowan SM, Bennell KL. Intrarater test-retest reliability of hip range of motion and hip muscle strength measurements in persons with hip osteoarthritis. Arch Phys Med Rehabil. 2008;89(6):1146–54.