A family of hypergeometric orthogonal polynomial sequences that contains all the families in the Askey scheme

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Abstract: We introduce a family $\mathcal{H}$ of hypergeometric orthogonal polynomial sequences determined by three polynomials h, f and g with degrees at most 1, 2, and 3, respectively, where some coefficients of g depend on the coefficients of h and f. The sequences in $\mathcal{H}$ satisfy a generalized difference equation of order one.

We express the orthogonal polynomials using the Newton basis associated with the sequence $f(n)$, for $n \geq 0$, and for every sequence in $\mathcal{H}$ we find an explicit hypergeometric representation, the three-term recurrence relation, and the generalized moments with respect to the Newton basis. When f is constant we obtain the classical orthogonal sequences. When f is not constant the sequences satisfy a discrete orthogonality relation and we find the discrete weight function.

The recurrence coefficients for each one of the 15 families of polynomial sequences in the Askey scheme of hypergeometric orthogonal polynomials are obtained by direct substitution of particular values for the parameters in our general formulas.